1912

THE

Carpenter's New Guide:

BEING A

COMPLETE BOOK OF LINES

FOR

CARPENTRY AND JOINERY.

TREATING FULLY ON

Practical Geometry, Soffits, Brick and Plaister Groins, Niches of every Description, Sky-lights, Lines for Roofs and Domes, with a great Variety of Designs for Roofs, Truffed Girders, Floors, Domes, Bridges, &c.;—Stair-cases and Hand-Rails of various Conftructions; Angle Bars for Shop Fronts, &c.; and Raking Mouldings; with many other Things entirely new.

The whole founded on true Geometrical Principles; the Theory and Practice well explained, and fully exemplified

ON SEVENTY-EIGHT COPPER-PLATES,

CORRECTLY ENGRAVED BY THE AUTHOR.

INCLUDING

SOME OBSERVATIONS AND CALCULATIONS ON THE STRENGTH OF TIMBER.

BY

PETER NICHOLSON.

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THE

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CARPENTRY AND JOINERY.

BIBLIOTHECA
REGIA
MONACENSIS.

PREFACE.

TO a book intended merely for the uſe of Practical Mechanics, much Preface is not neceſſary:—it is proper, however, to ſay, that whatever rules by previous authors have on examination proved to be true and well explained, theſe have been ſelected and adopted, with ſuch alterations as a very cloſe attention has warranted for the more eaſily comprehending them, for their greater accuracy or facility of application; added to theſe, are many examples which are entirely of my own invention, and ſuch as will, I am perſuaded, conduce very much to facilitate the workman, and to the accuracy of the work.

In this Second Edition the arrangement is gradual and regular, ſuch as a ſtudent ſhould purſue who wiſhes to attain a thorough knowledge of his profeſſion; and as it is Geometry that lays down all the firſt principles of building, meaſures, lines, angles, and ſolids, and gives rules for deſcribing the various kinds of figures uſed in buildings; therefore, as a neceſſary introduction to the art treated of, I have firſt laid down, and explained in the terms of workmen, ſuch problems of Geometry as are abſolutely requiſite to the well underſtanding and putting in practice the neceſſary lines for Carpentry. Theſe problems, duly conſidered, and their reſults well underſtood, the learner may proceed to the theoretical part of the ſubject, in which Soffits claim a very particular attention; for by a thorough knowledge of theſe, the ſtudent will be enabled to lay down arches which ſhall ſtand exactly perpendicular over their plan, whatever form the plan may be: on this depends the well executing all groins, arches, niches, &c. conſtructed in circular walls, or which ſtand upon irregular baſes; wherefore the importance of rightly underſtanding theſe I cannot ſufficiently inſiſt on, their conſtruction being ſo various and intricate, and their uſes ſo frequently required.

The next ſubject which regularly preſents itſelf is Groins; for the conſtruction of which there will be found many methods entirely new; and beſides the common figures, I have ſhewn many which are difficult of conſtruction, and not to be found in any other author. I have diſplayed a large aſſortment of niches of each kind;

theſe are frequently wanted, thoſe of the elliptic form only have yet been explained: in addition to theſe, here will be found ſchemes for globular ones, which occur frequently in practice.

Among the various methods for finding the Lines for Roofs, I have given an entire new one for finding the down and ſide bevels of purlines, ſo that they ſhall exactly fit againſt the hip rafter; and by the ſame method the jack rafter will be made to fit.

Of Domes and Polygons, I have ſhewn an entirely new method for finding their covering, within the ſpace of the board, thereby avoiding the tedious and incommodious method of finding the lines on the dome itſelf, as has been always practiſed heretofore; alſo a method for finding the form of the boards near the bottom, when a dome is to be covered horizontally. Of Dome-lights over ſtaircaſes, or in the centre of groins, a rule upon true principles is given, for finding their proper curve againſt the wall, and the curve of the ribs. This has never before been made public.

Having gone thus far in the Science of Carpentry (viz. through the theoretical part), it is neceſſary for me to ſay, by way of caution and guard to the ardent theoriſt, that there are on ſome ſurfaces curve lines which cannot be found abſolutely true to one another; ſuch as ſpherical or ſpheroidical domes, where their coverings cannot be found by any other means than by ſuppoſing them to become polygonal; in which caſe, they may be performed upon true principles, as may be demonſtrated.—Let us ſuppoſe a polygonal dome inſcribed in a ſpherical one; then, the greater the number of ſides of the polygonal dome, the nearer it will coincide with its circumſcribing ſpherical one.—Again, let us ſuppoſe that this polygon has an infinite number of ſides; then, its ſurface will exactly coincide with the ſpherical dome, and therefore in any thing which we ſhall have occaſion to practiſe, this method will be ſufficiently near; as for example, in a dome of one hundred ſides, of a foot each, the rule for finding ſuch a covering will give the practice ſo very near, that the variation from abſolute truth could not be perceived.

The Theory of Carpentry being now gone through, and I hope well ſtudied and attended to; for the young ſtudent muſt not expect to be perfect maſter of this

this intricate and important ſubject without ſome pains and application, notwithſtanding the plain and clear manner in which I have endeavoured to lay down and explain thoſe parts of his profeſſion, which, on account of their importance, claim his utmoſt attention; and obſerve, that, in order to combine theory and practice, as well as to vary and enliven the ſubject, I have uniformly, with the theory, given examples of the practice, yet keeping them diſtinct and ſeparate:

We now proceed to the Practical Part of Carpentry, in which is given a great variety of examples for floors, truſſes, girders, roofs, domes, and partitions, on the neweſt and beſt principles.

In that nice and elegant branch of the Building Art, called Joinery, Stairs and Hand-rails take the lead; and notwithſtanding the great importance of this ſubject, I am ſorry to find it has been treated, by authors in general, in a very clumſy and ſlovenly manner. For Stair-caſes, in general, I have laid down right methods, on principles entirely new, and which, ſince the publication of the former edition of this work, I have the ſatisfaction to ſay, have been put in practice, and found to anſwer well.

Various methods for diminiſhing Columns are ſhewn, together with two new ones, which I flatter myſelf are more eaſily adapted to practice; among other things of inferior note, is a method for finding the Lines of a circular Saſh in a circular wall; alſo, a method, to the ſame purpoſe, for Architraves in a circular wall; neither of which have before been given, or explained. For mitring raking mouldings, I have, with ſome pains, confirmed a true method, not merely in theory, but by models, which I have by me, and am willing to ſhew, at convenient ſeaſons, to any enquirer.

I muſt not here omit to obſerve, for though laſt not leaſt, that my ſpeculations and calculations on the ſtrength of timber, will, I hope, be found particularly uſeful; and not merely ſo, but may alſo tend to induce others to conſider this ſubject, whoſe leiſure and abilities may lead to more important diſcoveries: I beg leave to add, that, to confirm the mathematical calculations, I have tried ſeveral of the queſtions by experiments. He who is a perfect maſter of this branch, may err in decoration, but never can in ſtrength and proportion.

I beg leave to ſay of the Concluſion, it is intended to guard the young and incautious ſtudent againſt error; for wrong maxims are with more difficulty obliterated from the mind, than originally obtained.

To conclude; as I pretend not to infallibility, I hope to be judged with candour, being always open to conviction, from a knowledge of the difficulty and intricacy of ſcience; yet I hope that my labours may be of ſome uſe to others, in ſhortening the road, and ſmoothing the path through which, for ſeveral years, I have been a perſevering traveller for knowledge: I ſhall then be ſatisfied, and not deem time miſpent, if my labours tend to the public good.

P. NICHOLSON.

P. S. In this Second Edition the arrangement of the ſubjects is progreſſive and regular; and beſides eighteen additional plates, many of the others have been re-engraved, the ſubjects, in ſome, made more intelligible, and, in others, multiplied: So that this edition may be conſidered as a New Work.

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OF

OF

PRACTICAL GEOMETRY.

GEOMETRY is the ſcience of extenſion and magnitude; it teaches the conſtruction of all right lined and curvilineal figures, and is divided into Theoretical and Practical.

The Theoretical part is founded upon reaſon and ſelf-evidence; it demonſtrates the conſtruction of variouſly formed figures, and evinces the truth, or detects the falſehood on which they are made. This is the foundation of the Practical part; and without a knowledge of the Theory, no invention to any degree certain can be made in the Practice. The uſes of Geometry are not confined to Carpentry and Architecture, but, in the various branches of the Mathematics, it opens and diſcovers to us their ſecrets. It teaches us to contemplate truths, to trace the chain of them, ſubtle and almoſt imperceptible as it frequently is, and to follow them to the utmoſt extent.

Its uſes are great and neceſſary in Aſtronomy and Geography. The ſcience of Perſpective is entirely dependent upon its principles. To enumerate its many uſes is beyond my power. Thoſe who deſire to become thoroughly acquainted with Geometry, will do well to ſtudy attentively the Elements of Euclid.

As my labours are not intended for the abſtruſe Mathematician, but for the inſtruction of the *Practical Carpenter*, I ſhall omit all ſpeculative demonſtrations, the ſections of Cylinders and Globes excepted (which are not to be found in Euclid), and confine myſelf to the uſeful part of the ſcience, viz. PRACTICAL GEOMETRY.

PLATE I.

DEFINITIONS.

1. *A POINT hath neither parts nor magnitude.*

2. *A line is length, without breadth or thickneſs.*

3. *A ſuperficies*

3. *A ſuperficies hath length and breadth only.*

4. *A ſolid is a figure of three dimenſions, having length, breadth, and thickneſs.*

Hence ſurfaces are the extremities of ſolids, and lines the extremities of ſurfaces, and points the extremities of lines.

5. *Lines are either right, curved, or mixed of theſe two.*

6. *A right or ſtraight line lies all in the ſame direction between its extremities, and is the ſhorteſt diſtance between two points, as* A.

7. *A curve continually changes its directions between its extreme points, as* C.

8. *Lines are either parallel, oblique, perpendicular, or tangential.*

9. *Parallel lines are always at the ſame diſtance, and will never meet, though ever ſo far produced, as* D and E.

10. *Oblique right lines change their diſtance, and would meet, if produced, as* F.

11. *One line is perpendicular to another when it inclines no more to one ſide than another, as* G.

12. *One line is a tangent to another when it touches it without cutting, when both are produced, as* H.

13. *An angle is the inclination of two lines towards one another in the ſame plane, meeting in a point, as* I.

14. *Angles are either right, acute, or oblique, as* K.

15. *A right angle is that which is made by one line perpendicular to another, or when the angles on each ſide are equal, as* G.

16. *An acute angle is leſs than a right angle, as* K.

17. *An obtuſe angle is greater than a right angle, as* L.

18. *A ſuperficies is either plane or curved.*

19. *A plane, or plane ſurface, is that to which a right line will every way coincide;—but if not, it is curved.*

20. *Plane figures are bounded either by right lines or curves.*

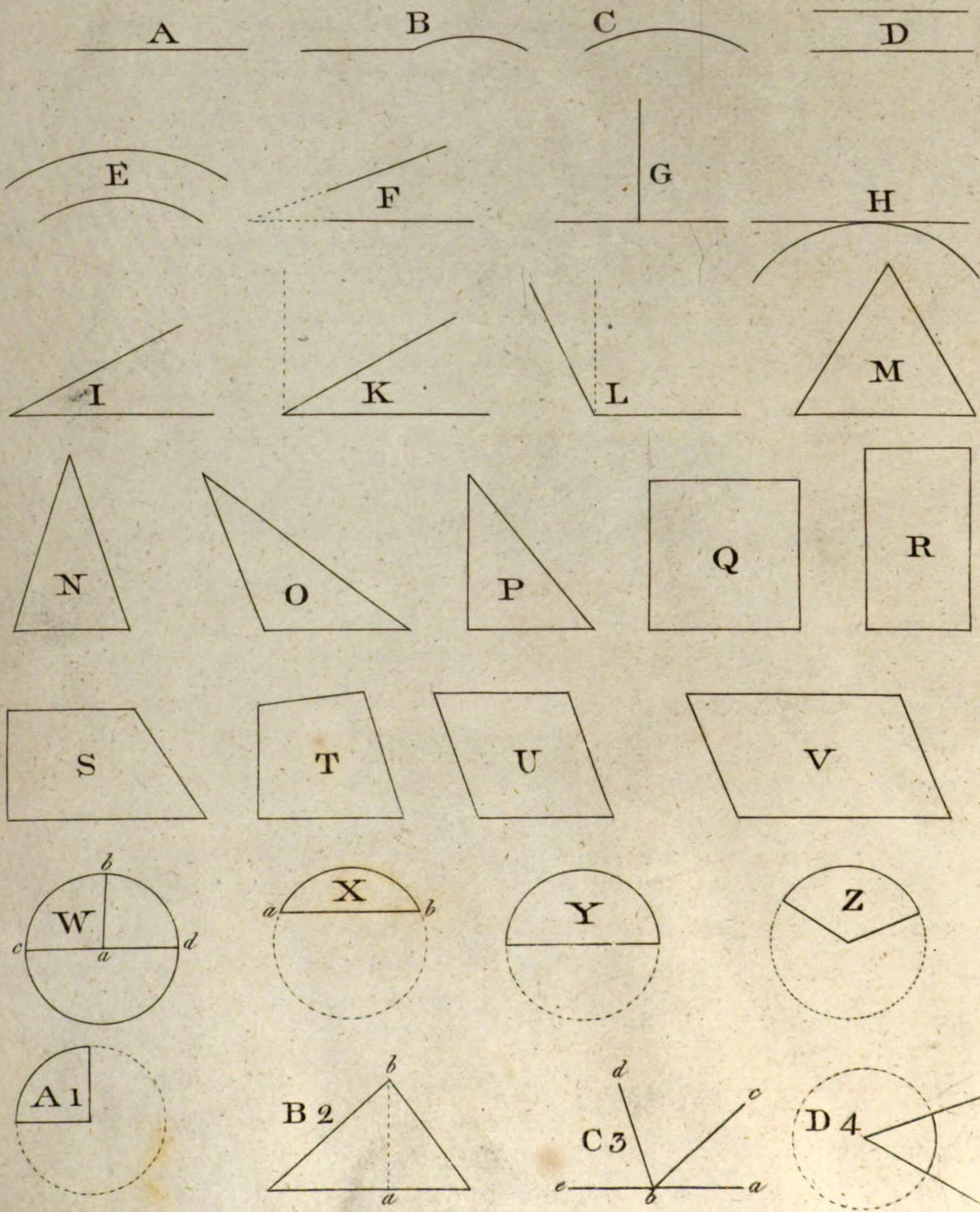
21. *A ſolid is ſaid to be cut by a plane when it is cut through in any particular place, and the place that is cut is called the ſection of the ſolid.*

22. *Plane figures, bounded by right lines, have names according to the number of their ſides, or of their angles, for they have as many ſides as angles—the leaſt number is three.*

23. *An equilateral triangle is that whoſe three ſides are equal, as* M.

24. *An*

Plate 1



24. *An iſoſceles triangle has only two ſides equal, as* N.

25. *A ſcalene triangle has all ſides unequal, as* O.

26. *A right angled triangle has one right angle, as* P.

27. *Other triangles are oblique angled, and are either obtuſe or acute.*

28. *An acute angled triangle has all its angles acute, as* M *or* N.

29. *An obtuſe angled triangle has one obtuſe angle, as* O.

30. *A figure of four ſides and angles is called a quadrangle, or quadrilateral, as* Q, R, S, T, U *and* V.

31. *A parallelogram is a quadrilateral, which has both pairs of its oppoſite ſides parallel, as* Q, R, U *and* V ; *and takes the following particular names.*

32. *A rectangle is a parallelogram having all its angles right ones, as* Q *and* R.

33. *A ſquare is an equilateral rectangle, having all its ſides equal, and all its angles right ones, as* Q.

34. *A rhombus is an equilateral parallelogram, whoſe angles are oblique, as* U.

35. *A rhomboid is an oblique angled parallelogram, as* V.

36. *A trapezium is a quadrilateral which has neither pair of its ſides parallel, as* T.

37. *A trapezoid hath only one pair of its oppoſite ſides parallel, as* S.

38. *Plane figures having more than four ſides, are in general called polygons, and receive other particular names according to the number of their ſides or angles.*

39. *A pentagon is a polygon of five ſides, a hexagon hath ſix ſides, a heptagon ſeven, an octagon eight, a nonagon nine, a decagon ten, an undecagon eleven, and a dodecagon twelve ſides.*

40. *A regular polygon hath all its ſides and its angles equal; and if they are not equal, the polygon is irregular.*

41. *An equilateral triangle is alſo a regular figure of three ſides, and a ſquare is one of four; the former being called a trigon, and the latter a tetragon.*

42. *A circle is a plane figure bounded by a curve line called the circumference, which is everywhere equidiſtant from a certain point within, called its centre.*

43. *The radius of a circle is a right line drawn from the centre to the circumference, as* a b *at* W.

44. *A diameter of a circle is a right line drawn through the centre, terminating on both ſides of the circumference, as* c d *at* W.

45. *An arch of a circle is any part of the circumference.*

46. *A chord is a right line joining the extremities of an arch, as* a b *at* X.

47. *A ſegment is any part of a circle bounded by an arch and its chord, as* X.

48. *A ſemicircle is half the circle, or a ſegment cut off by the diameter, as* Y.

49. *A ſector is any part of a circle bounded by an arch and two radii, drawn to its extremities, as* Z.

50. *A quadrant, or quarter of a circle, is a ſector having a quarter of the circumference for its arch, and the two radii are perpendicular to each other, as* A 1.

51. *The height or altitude of any figure is a perpendicular let fall from an angle, or its vertex, to the oppoſite ſide, called the baſe, as* a b *at* B 2.

52. *When an angle is denoted by three letters, the middle one is the place of the angle, and the other two denote the ſides containing that angle; thus let* a b c *be the angle at* C 3, b *is the angular point, and* a b *and* b c *are the two ſides containing that angle.*

53. *The meaſure of any right lined angle is an arch of any circle contained between the two lines which form the angle, and the angular point being in the centre, as* D 4.

PLATE II.

PROBLEMS.

FIGURE 1. *To draw a perpendicular to a given point in a line.*

A B is a line, and *c* a given point; take *a* and *b*, two equal diſtances on each ſide of *c*, and with your compaſſes in *a* and *b* make an interſection *d*, and draw *d c*, which is the perpendicular.

FIG. 2. *To make a perpendicular with a ten foot rod.*

Let *a b* be ſix feet, then take eight feet and make an arch at *c* in the point *b*, and in the point *a* with the diſtance ten feet croſs at *c*, then draw *c b*, which is the perpendicular.

FIG. 3. *To let fall a perpendicular from a given point to a line.*

In the given point *c* make an arch to croſs the line in *a* and *b*, and in *a* and *b* make an interſection at *d*, and draw *c d*, the perpendicular.

FIG. 4. *To draw a perpendicular upon the end of a line*

Take any point at pleaſure above the line, and with the diſtance *d b* make an arch *a b c*, and draw a line *a d* to croſs it at *c*, and draw *c b* the perpendicular.

FIG. 5.

Plate 2.

Fig. 1.

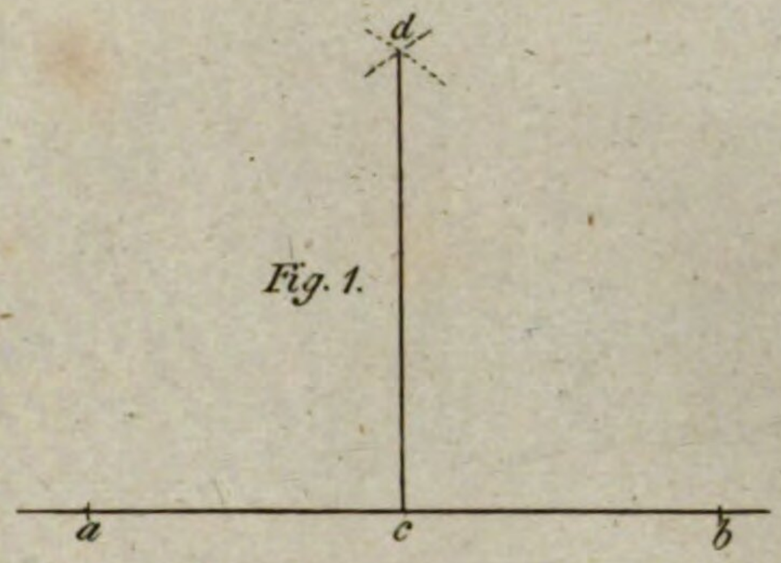


Fig. 2.

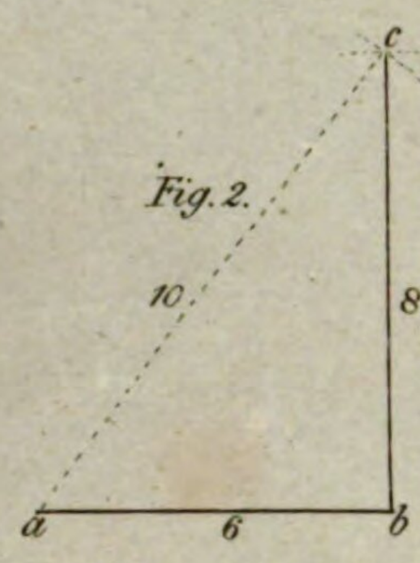


Fig. 3.

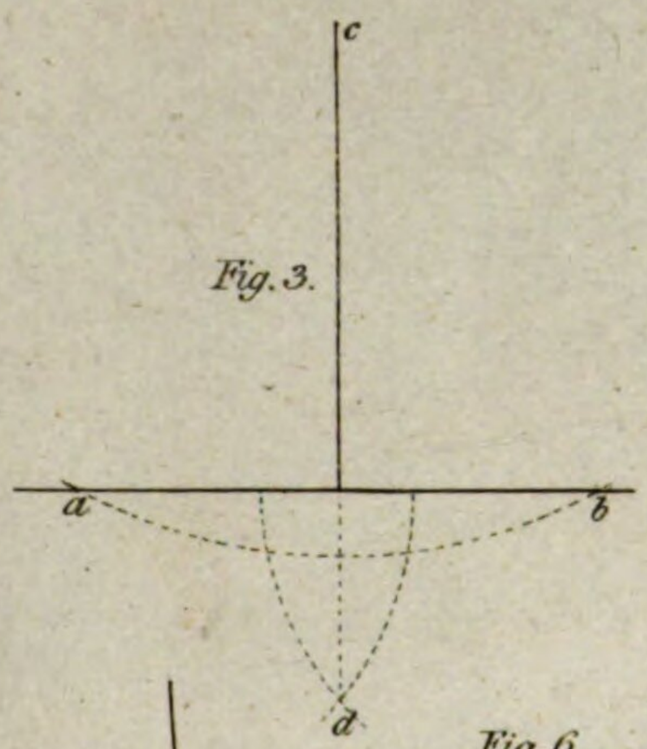


Fig. 4.

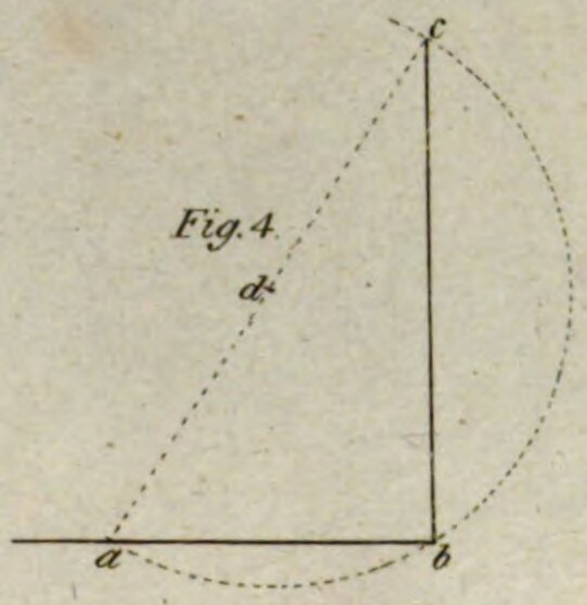


Fig. 5.

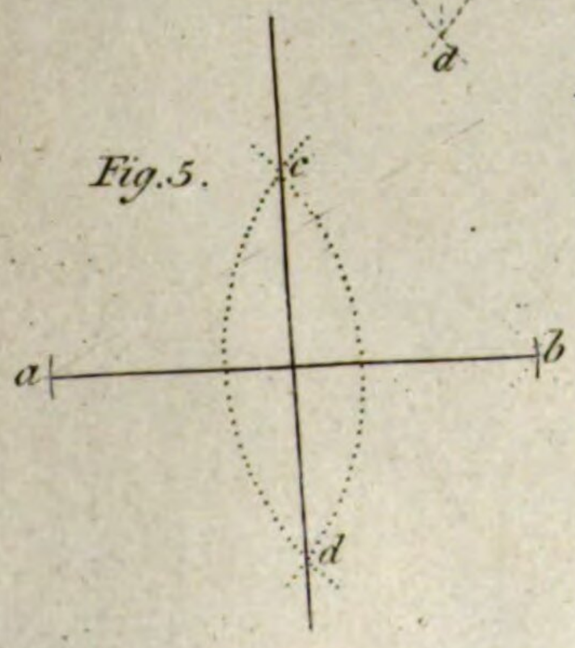


Fig. 6.

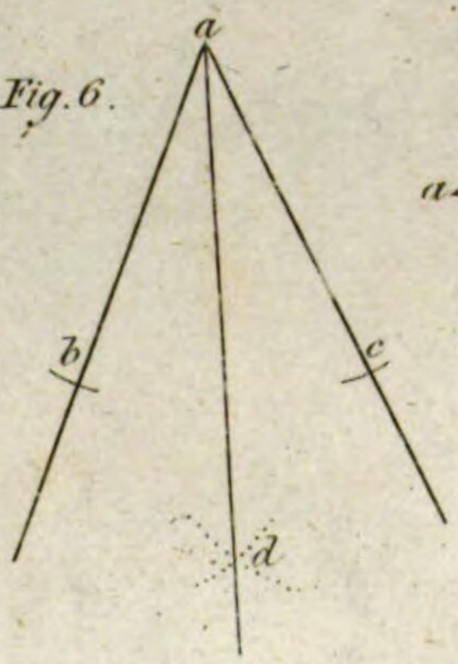
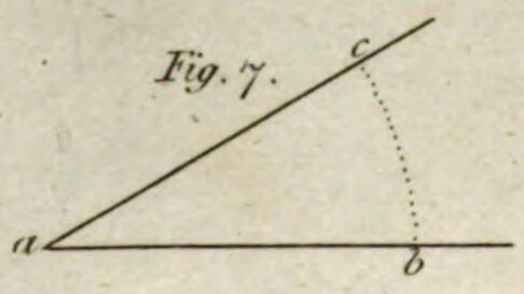


Fig. 7.



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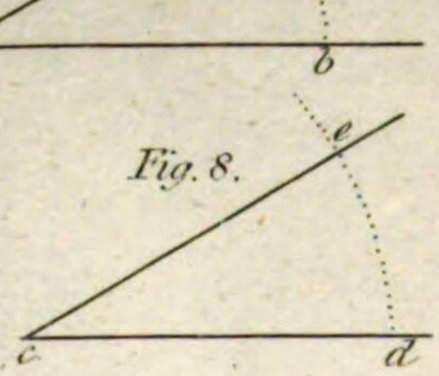

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Plate 3

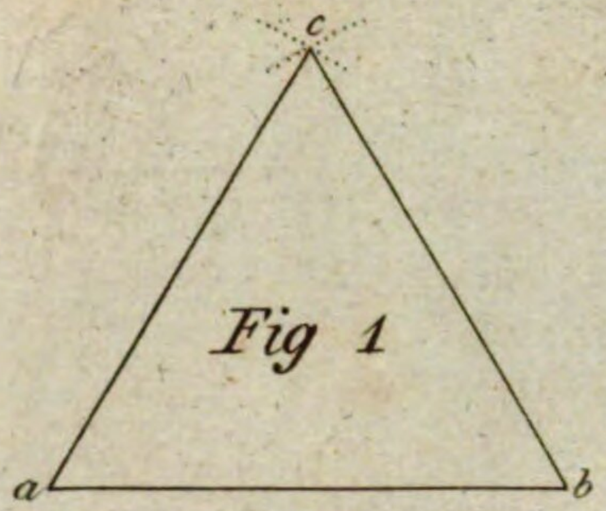


Fig 1

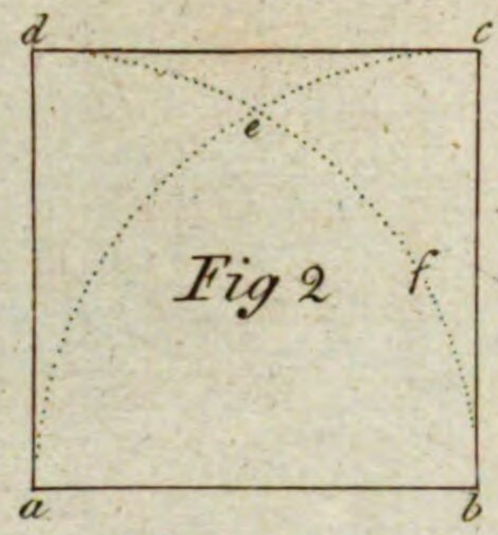


Fig 2

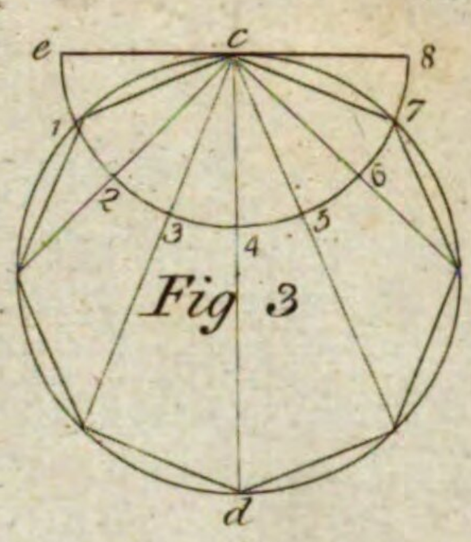


Fig 3

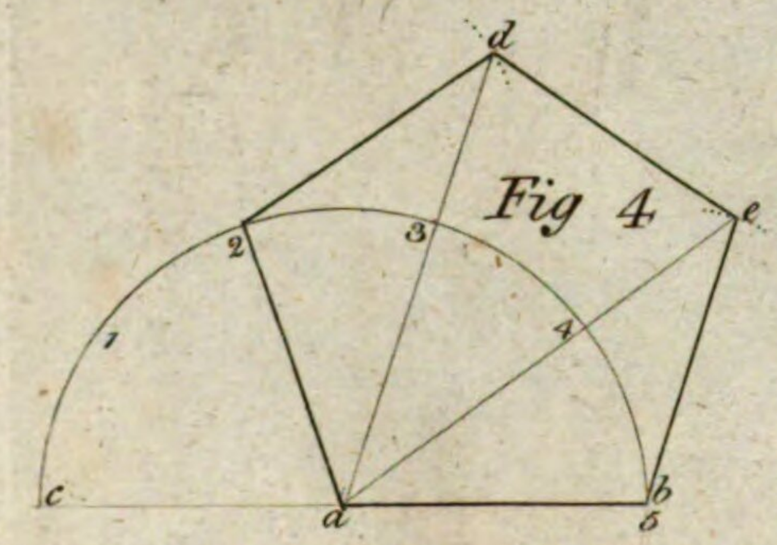


Fig 4

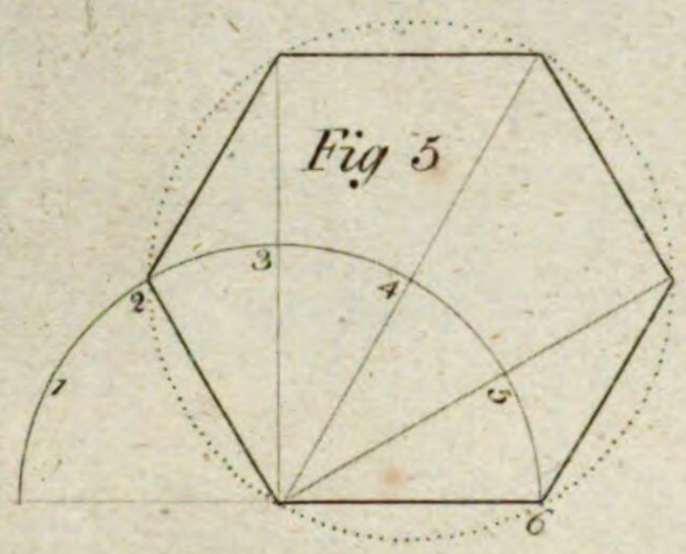


Fig 5

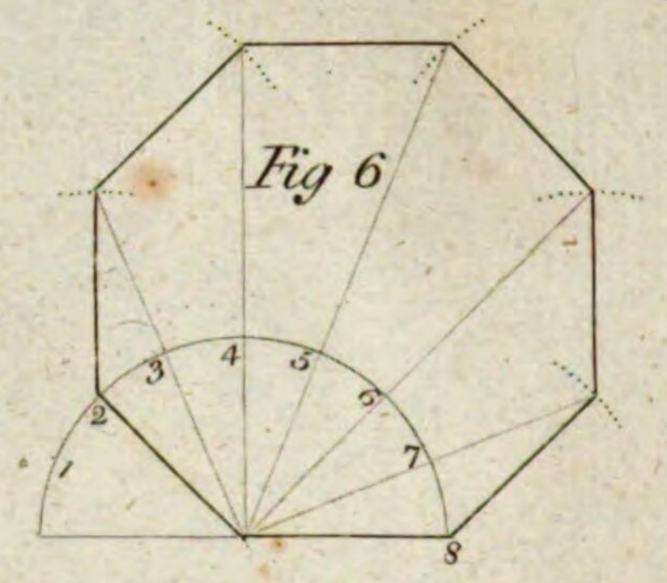


Fig 6

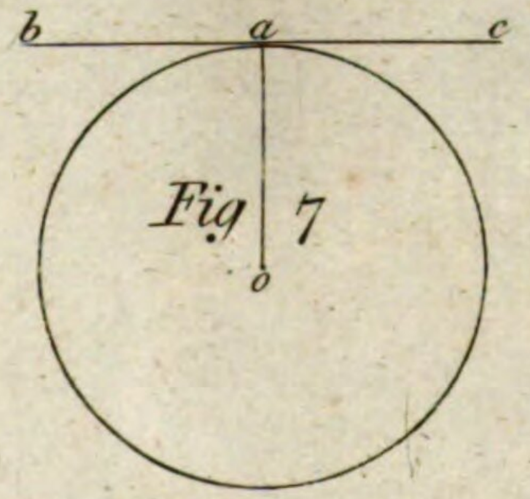


Fig 7

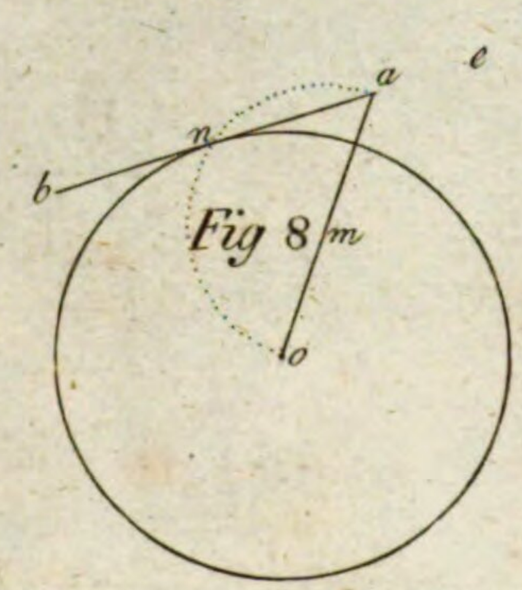


Fig 8

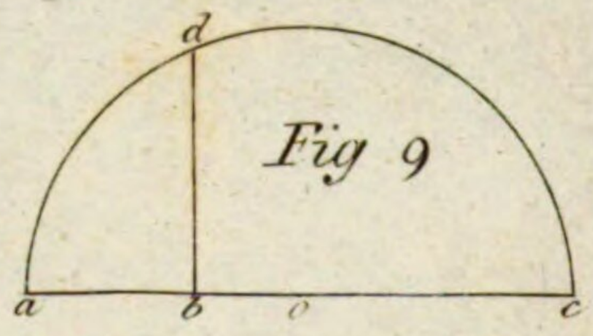


Fig 9

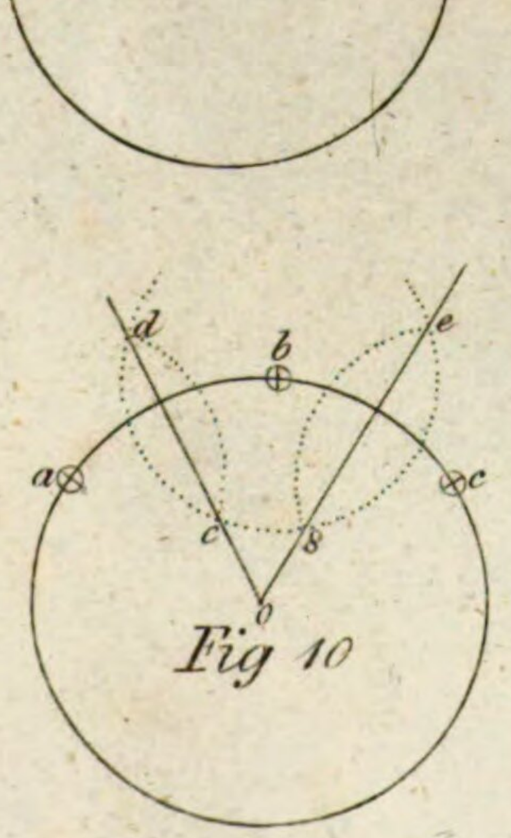


Fig 10

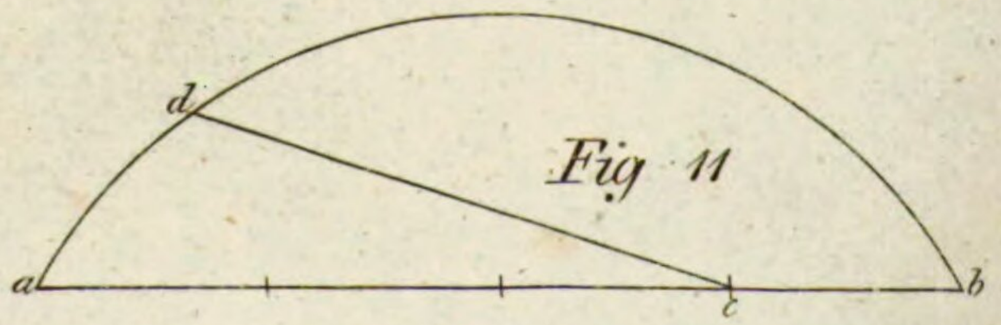


Fig 11

FIG. 5. *To divide a line in two parts by a perpendicular.*

In the points *a* and *b* deſcribe two arches to interſect at *c* and *d*, and draw *c d*, which divides the line in two.

FIG. 6. *To divide any given angle into two equal angles.*

Take two equal diſtances *b* and *c* on each ſide of the angular point *a*, and with the ſame opening of the compaſs on any other place the foot of your compaſs in *b* and *c*, make an interſection at *d*, and draw *d a*, which will divide the angle into two equal parts.

FIG. 7 and 8. *An angle being given, to make another equal to it, from a given point, in a right line.*

Let *b a c* be the angle given, and *c d* a right line, *c* the given point; on *a* make an arch *b c* with any radius, and on *c* with the ſame radius deſcribe an arch *d e*, take the opening of *b c*, ſet it from *d* to *e*, and draw *e c*, then the angle *e c d* will be equal to *c a b*.

PLATE III.

FIG. 1. *Upon a right line to make an equilateral triangle.*

Take *a b* the given ſide with your compaſs, place one foot in *a* and *b*, make an interſection at *c*, and draw *c a* and *c b*.

FIG. 2. *Upon a right line to make a geometrical ſquare.*

With the given ſide *a b*, and in the points *a b*, deſcribe two arches to interſect at *e*, divide *b e* into two equal parts at *f*, make *e d* and *e c* each equal to *e f*, draw *a d*, *d c*, and *c b*.

FIG. 3. PROPOSITION.

If through the point c *in the extreme of the diameter* c d, *is drawn a tangent line* e c 8, *and if on this point* c *with any radius a ſemicircle be deſcribed and divided into equal parts, and from the centre* c *lines be drawn through theſe points to terminate in the circumference, it will be divided into equal parts.*

FIG. 4, 5, 6. *The ſide of any polygon being given, to deſcribe the polygon to any number of ſides whatever.*

On one extreme of the given ſide make a ſemicircle of any radius, but it will be moſt convenient to make it equal to the ſide of the polygon; then divide the ſemicircle into the ſame number of equal parts as you would have ſides in the polygon, and draw lines from the

the centre through the equal diviſions in the ſemicircle, always omitting the two laſt, and run the given ſide round each way upon theſe lines, join each ſide, and it will be completed.

Example in a pentagon, Fig. 4.

Let *a b* be the given ſide, and continue it out to *c;* on *a*, as the centre and the given ſide, deſcribe a ſemicircle, divide it into five equal parts, through 2, 3, 4, draw *a* 2, *a d*, *a e*, make *b e* equal to *a b*, 2 *d* equal to 2 *a* or *a b*, join 2 *d*, *d e*, and *e b*. In the ſame manner may any other polygon be deſcribed.

FIG. 7. *Through a given point* a *to draw a tangent to a given circle.*

From *a* draw *a o* to the centre, then through *a* draw *b c* perpendicular to *a o*, it will be the tangent.

FIG. 8. *A tangent line being given, to find the point where it touches the circle.*

From any point *a* in the tangent line *b c*, draw a line to the centre *o*, and divide *a o* into two equal parts at *m*, and with a radius *m a*, or *m o*, deſcribe an arch, cutting the given circle in *n*, which is the point required.

FIG. 9. *Two right lines being given, to find a mean proportion.*

Join *a b* and *b c* in one ſtraight line, divide it into two equal parts at the point *o*, with the radius *o a* or *o c* deſcribe a ſemicircle, and erect the perpendicular *b d*, then is *a b* to *b d* as *b d* is to *b c*.

FIG. 10. *Through any three points to deſcribe the circumference of a circle.*

From the middle point *b* draw chords *b a* and *b c* to the two other points *a* and *c*, divide the chords *a b* and *b c* into two equal parts by perpendiculars meeting at *o*, which will be the centre.

FIG. 11. *To find a right line equal to any given arch of a circle.*

Divide the chord *a b* into four equal parts, ſet one part *b c* on the arch from *a* to *d*, and draw *d c*, which will be nearly equal to half the arch.

Note. This method ſhould not be uſed above a quarter of a circle; ſo that if you would find the circumference of a whole circle by this method, the fourth part muſt only be uſed, which will give one eighth part of the whole exceedingly near.

PLATE IV.

FIG. 1. *Any three lines being given, to make a triangle.*

Take one of the given ſides *a b*, and make it the baſe of the triangle; take the other ſide

Plate 4.

Fig. 1.

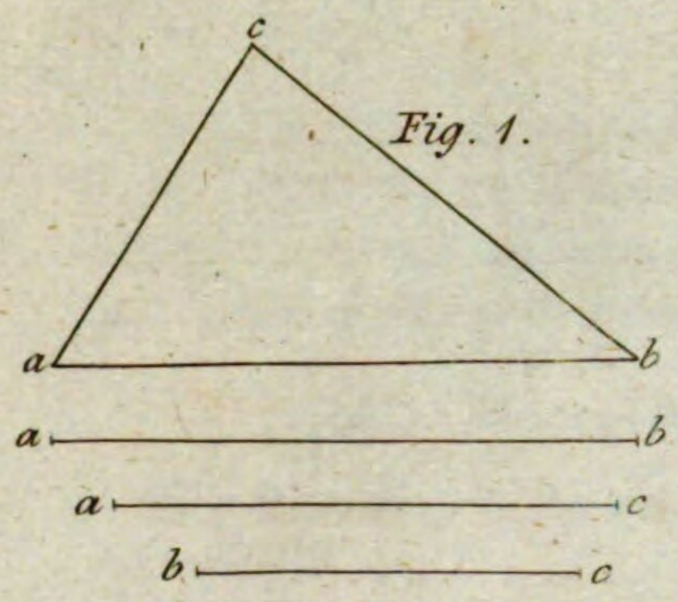


Fig. 2.

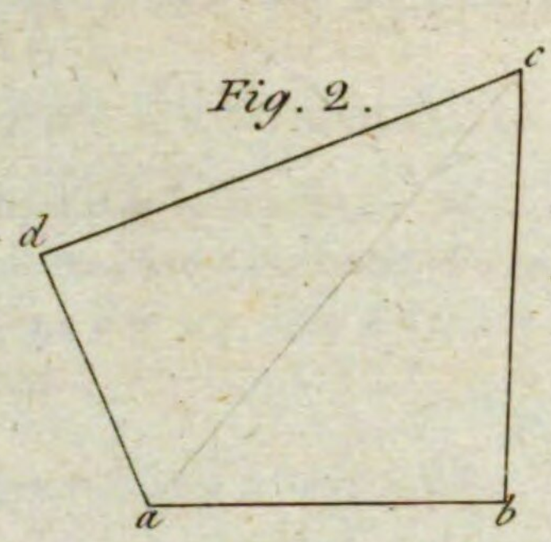


Fig. 3.

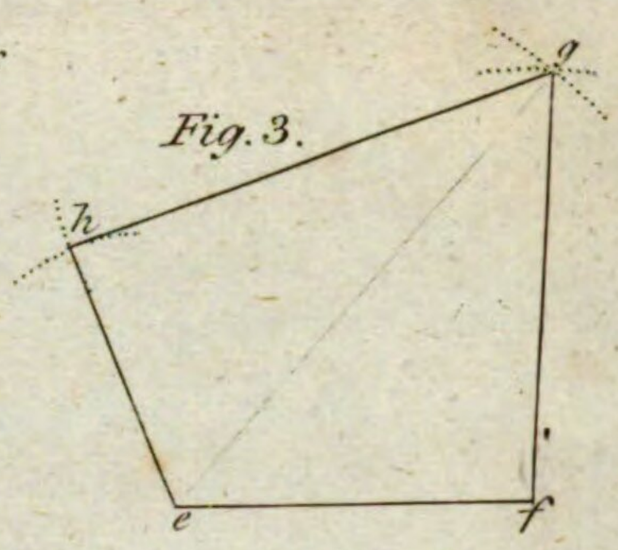


Fig. 4.

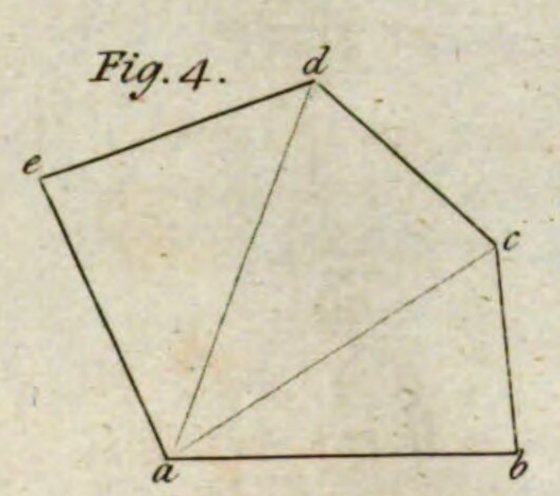
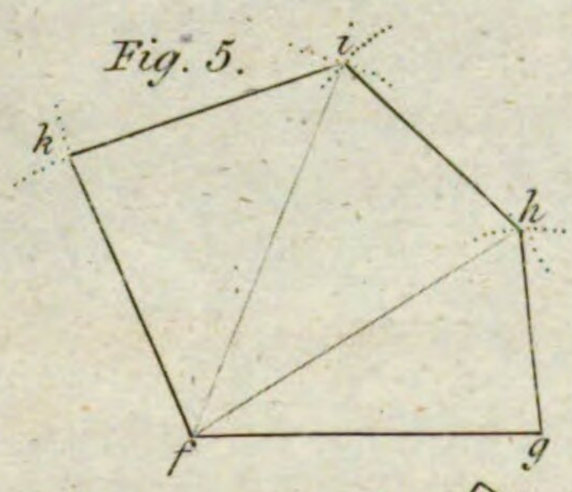


Fig. 5.



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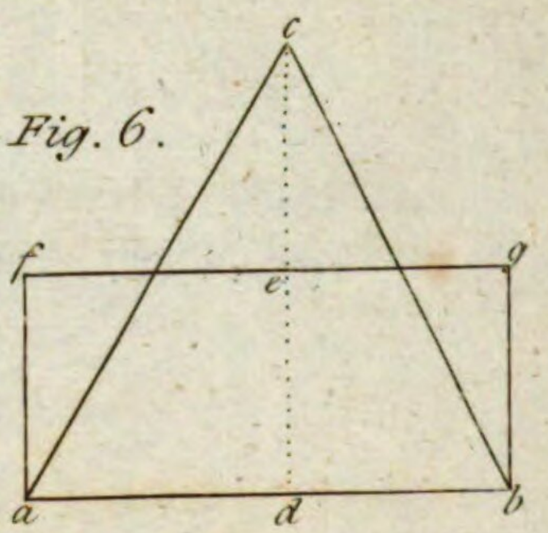

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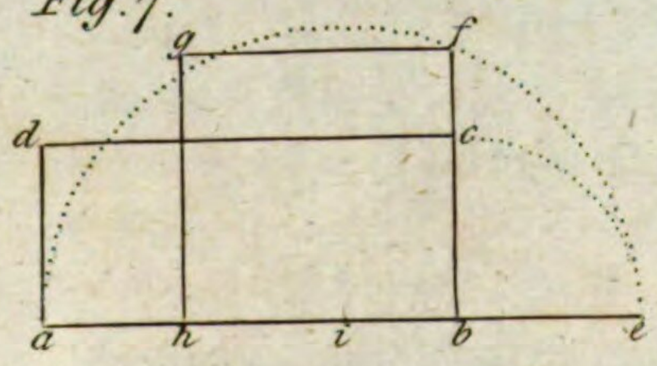

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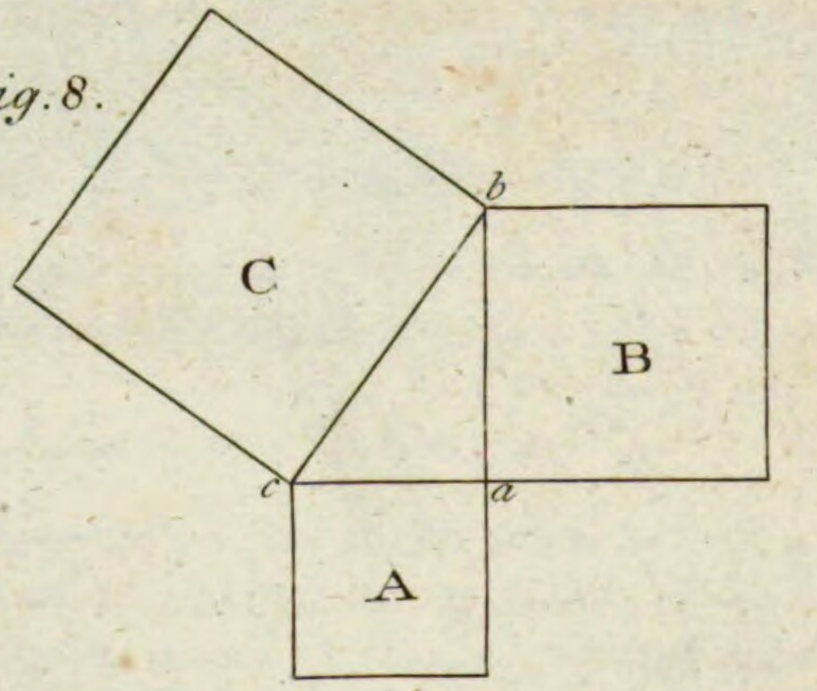
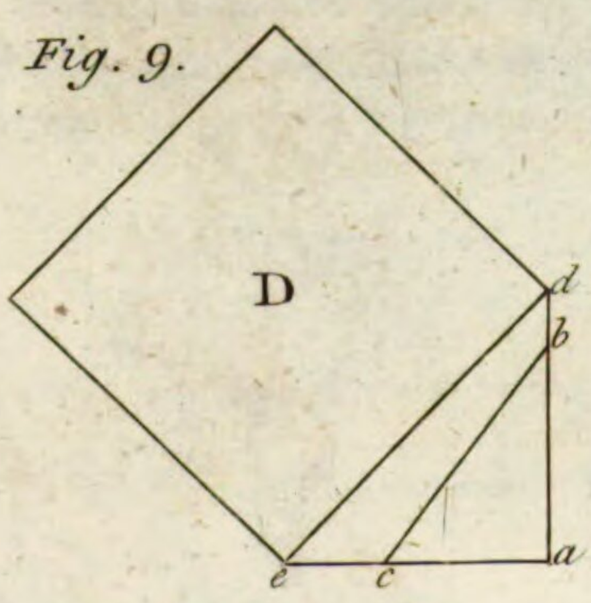
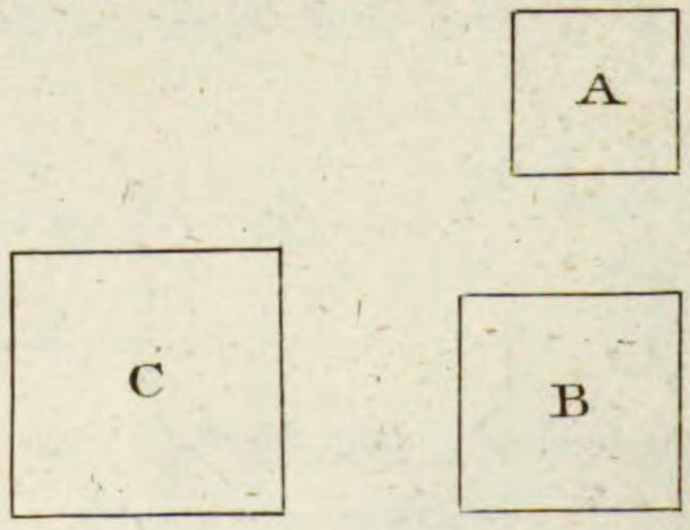


Fig. 9.





a c, and put the foot of the compaſs in *a*, and make an arch at *c*; then take the third ſide *b c*, and put the foot of the compaſs in *b*, and croſs the other arch at *c*; join the ſides.

Note: That any two lines muſt be greater than a third.

FIG. 2, 3. *To make a quadrangle equal to a given quadrangle.*

Divide the given quadrangle, *fig.* 2, in two triangles; make the triangle *e g f* equal to *a b c*, and *e g h* equal to *a c d*, and it is done.

FIG. 4, 5. *Any irregular polygon being given, to make another of the ſame dimenſions.*

Divide the given polygon into triangles, and in *fig.* 5, make triangles in the ſame poſition, reſpectively equal to thoſe in *fig.* 4; then will the irregular polygon *f, g, h, i, k*, be equal and ſimilar to *a b c d e*: in the ſame manner may any other polygon be made equal and ſimilar to another.

FIG. 6. *To make a rectangle equal to a given triangle.*

Draw a perpendicular *c d*, divide it into two equal parts at *e*, through *e* draw *f g*, parallel to the baſe *a b*, draw *a f*, *b g*, perpendicular; then will the rectangle *a b g f* be equal to the triangle *a b c*.

FIG. 7. *To make a ſquare equal to a given rectangle.*

Let *a b c d* be the given parallelogram; continue one of its ſides as *a b* out to *h*, make *b e* equal to the other ſide *b c*, divide *a e* in two equal parts at *i*, with the radius *i e* or *i a* make a ſemicircle *a f e*, and draw *b f* perpendicular to *a b*; make the ſquare *b f g h*, which is equal to the parallelogram *a b c d*.

FIG. 8. *To make a ſquare equal to two given ſquares.*

Make the perpendicular ſides *a c* and *a b* of the right angled triangle *a b c* equal to the ſides of the given ſquares *A* and *B*, draw the hypotenuſe *c b*, which is the ſide of the ſquare *C*, equal to the two ſquares *A* and *B*. In the ſame manner may a ſemicircle be made equal to two given ſemicircles, or any ſimilar figures whatever.

FIG. 9. *To make a ſquare equal to three given ſquares.*

Let *A B C* be the three ſquares; make *a b* equal to the ſide of *B*, *a c* equal to the ſide of *A*, at right angles to *a b* join *b c*, then make *a d* equal to *b c*, make *a e* equal to the ſide of *C*, join *d e*, which will be the ſide of the ſquare *D* equal to the ſquares *A B C*.

PLATE

PLATE V.

FIG. 1. *To draw a ſegment of a circle to any length and height.*

A b is the length, *i h* the height; divide the length *a b* into two parts by a perpendicular, divide *a h* by the ſame method, then their meeting at *g* will be the centre; fix the foot of the compaſſes in *g*, extend the other leg to *h*, make the arch *a h b*, which is the ſegment.

FIG. 2. *To draw a ſegment by rods, to any length and height.*

Get two rods *c e* and *c f*, each equal to *a b* the opening; place them to the height at *c*, and to the ends *a b*, put a piece acroſs them to keep them tight, then move your laths round the points *a b*, and it will deſcribe the ſegment at the point *c*.

FIG. 3. *To deſcribe a ſegment of a circle at twice, upon true principles, by a flat triangle.*

Let the extent of the ſegment be *a b*, its height *c d*, from the extreme *b* to the top *d* draw *b d*, through the point *d* draw *e d* parallel to the baſe *a b*, equal in length to *d b*, deſcribe one half, as you ſee at *G*; then move your nail, or pin, out of *a*, ſtick it in the point *b*, and deſcribe the other half.

FIG. 4. *The tranſverſe and conjugate axis of an ellipſis being given, to draw its repreſentation.*

Draw *a d* parallel and equal to *n c*, biſect it in *e*; draw *e c* and *d g* cutting each other at *m*, join *m c*, biſect it by a perpendicular meeting *e g*, produced at *h*; draw *h d*, cutting *b a* at *k*, and make *n i* equal to *n k*; *n l* equal to *n h*; through the points *i*, *l*, *k*, *h*, draw the lines *h i*, *k l*, and *i l*, *h k*, then deſcribe the four ſectors by help of the centres *i l k h*, and it will be the repreſentation required.

FIG. 5. *To deſcribe an ellipſis by ordinates.*

Make a ſemicircle on the length *a b*, divide it into any number of equal parts, as 16, on the end at *a*, make *a* 8 perpendicular, equal to half the width, and draw the ordinates through all the points in the ſemicircle, draw the line 8 1 to the centre, then *a* 1 8 will be a ſcale to ſet your oval off; take 1 1 from your ſcale, and ſet it from 1 to 1 in your oval both ways at each end; then take 1 2 in your ſcale, and ſet it to 1 2 in your oval, and find all the other points in the ſame manner; a curve being traced through theſe points will be the true ellipſis.

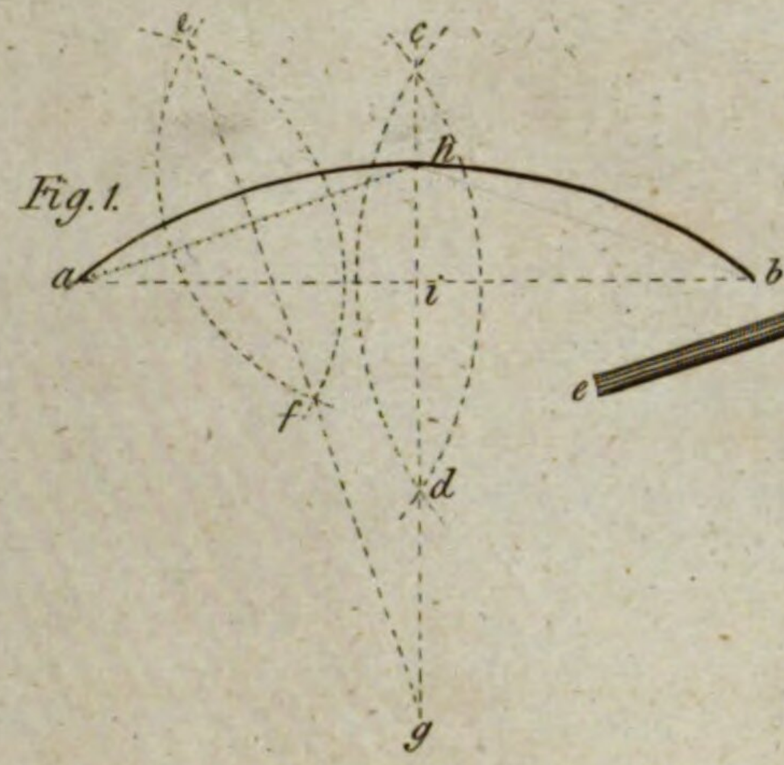
PLATE VI.

FIG. 1. *To make an ellipſis with a ſtring.*

Take half the longeſt diameter *a b*, that is, *a g*, with that diſtance fix the foot of the

Plate 5.

Fig. 1.



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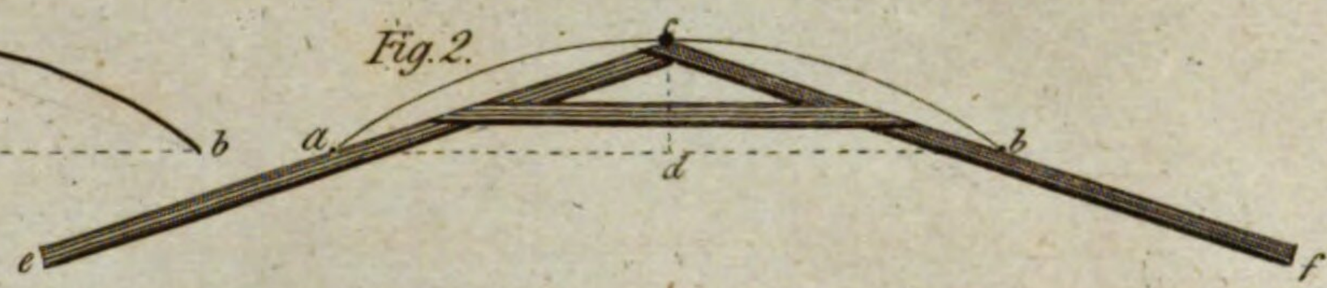

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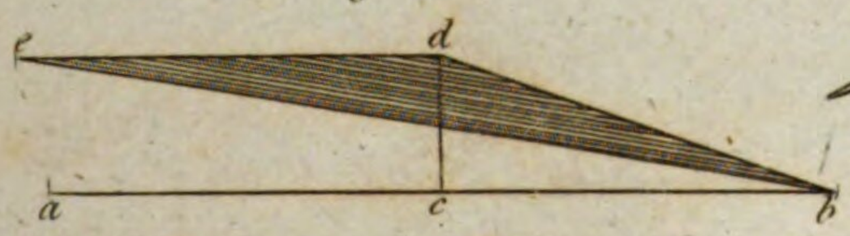

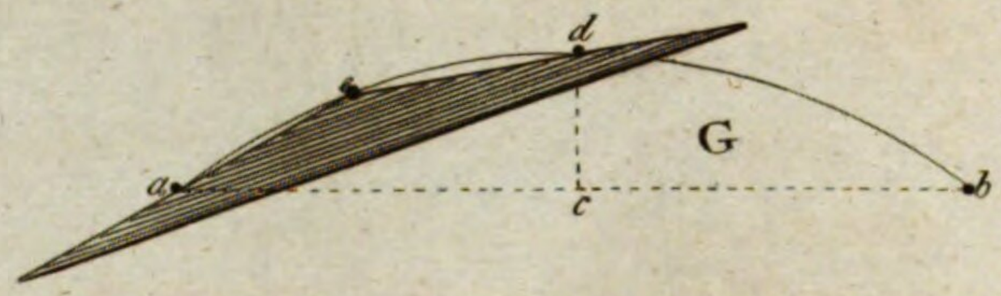

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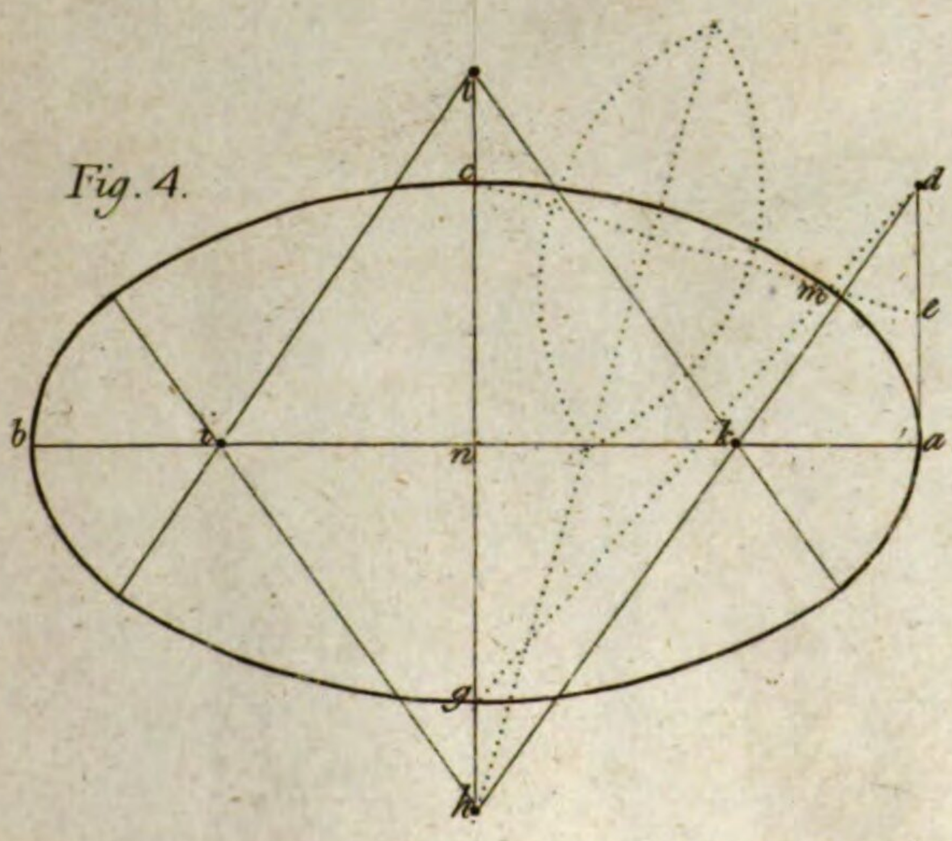

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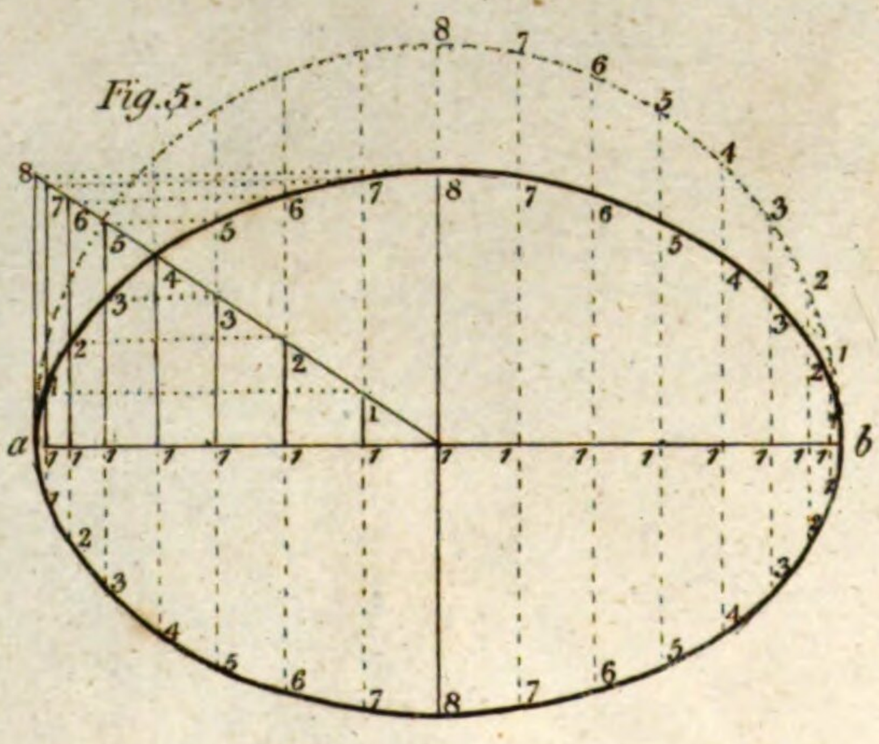

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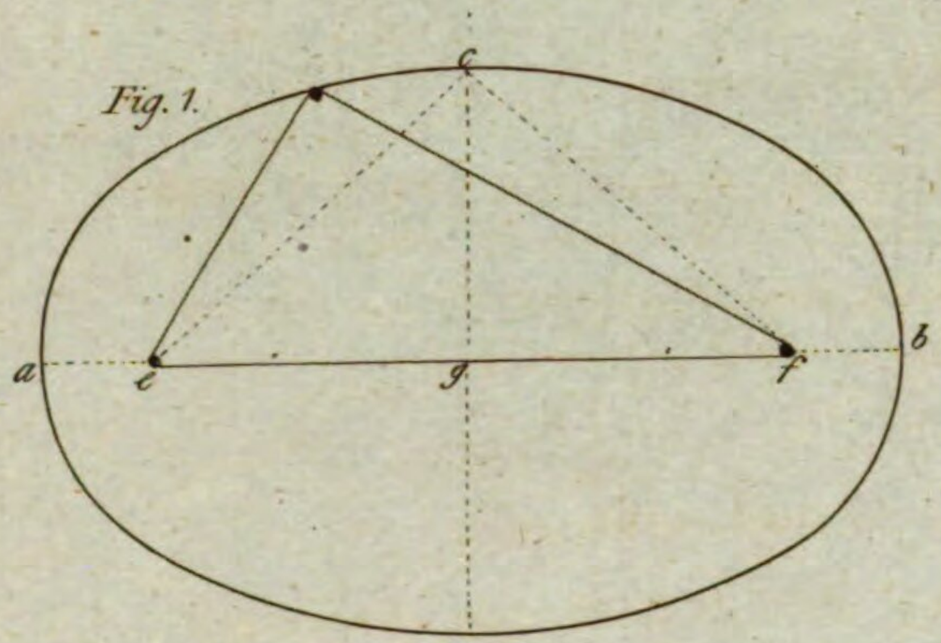
Plate 6.

Fig. 1.



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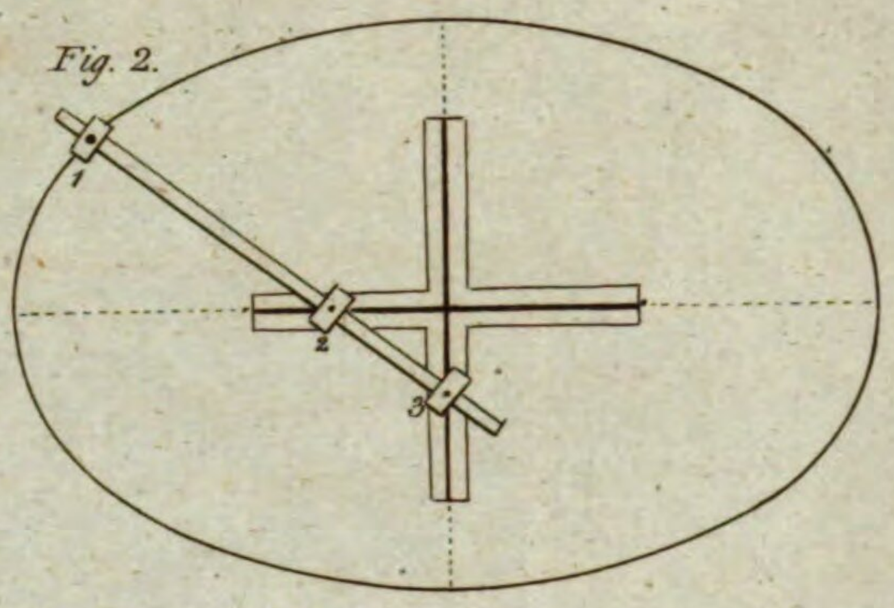

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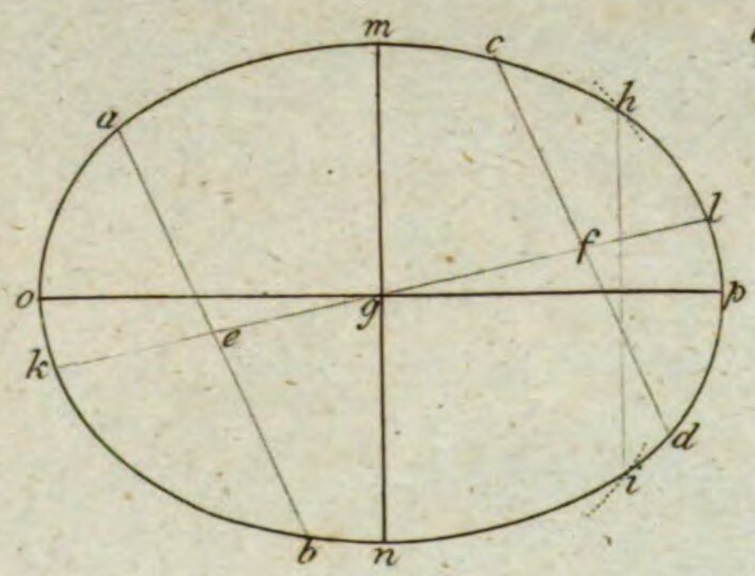

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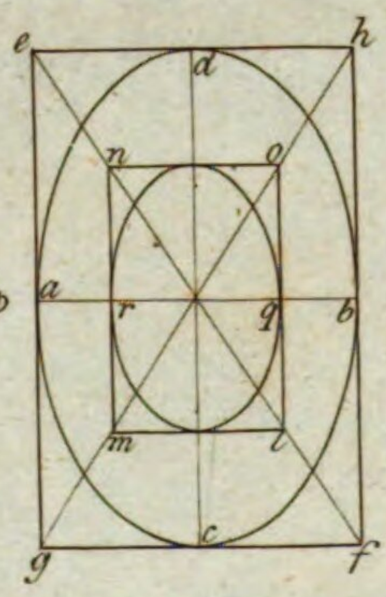

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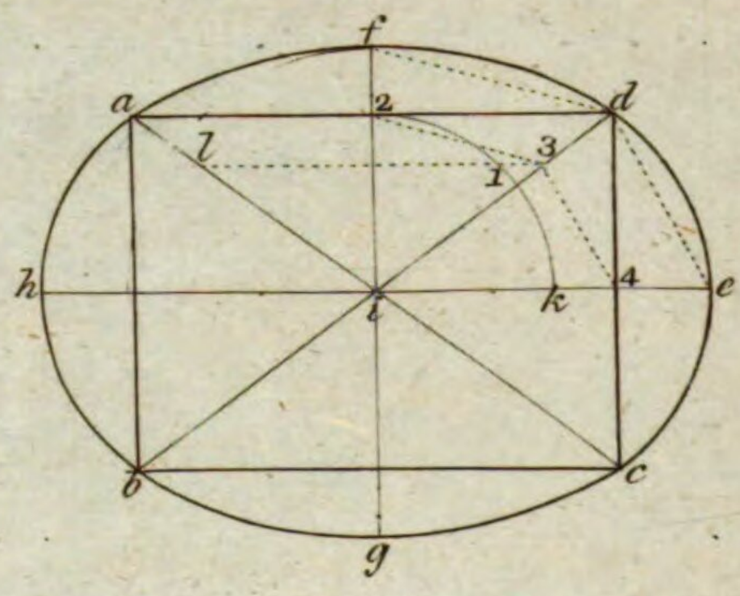

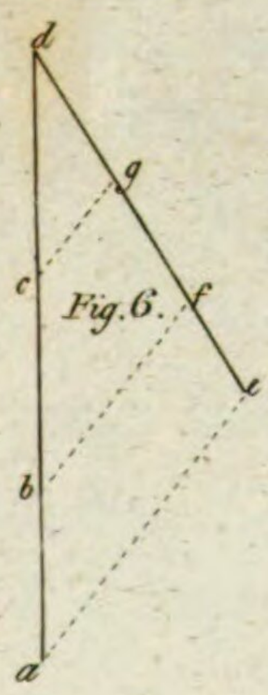

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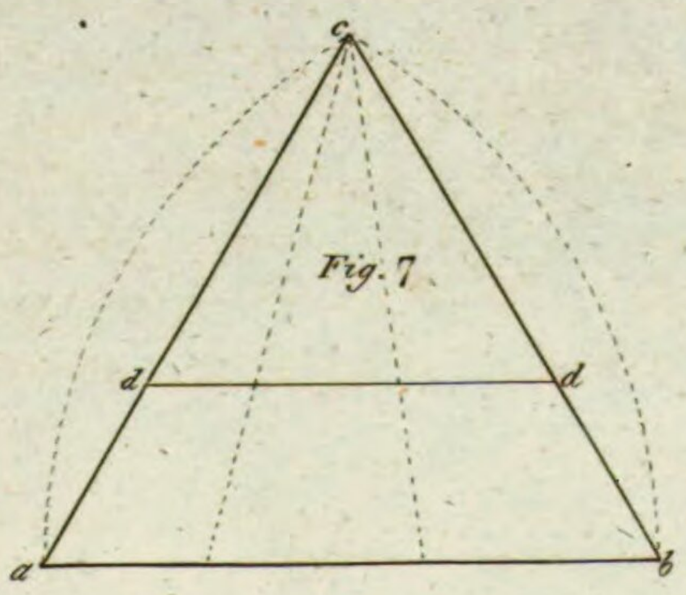

Fig. 7

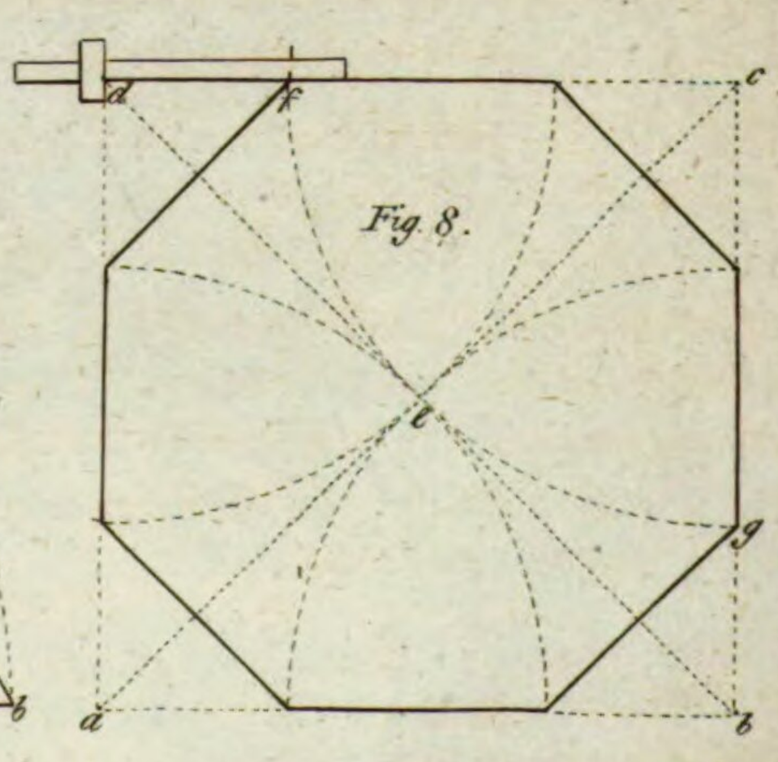

Fig. 8.

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compaſs in *c*, croſs *a b* at *e f*, ſtick in two nails or brads, then lay a ſtring at *e f* to come out to *c*, fix a pencil at *c*, and move your hand round, keeping the ſtring tight, will deſcribe the ellipſis.

FIG. 2. *To deſcribe an ellipſis by a trammel.*

1 2 3 is a trammel rod, at 1 is a nut with a hole to hold a pencil; at 2 and 3 are two other ſliding nuts; make the diſtance of 2 from 1, half the ſhorteſt diameter of your ellipſis, and from the nut 1 to 3 equal to half the longeſt, the points 2 and 3 being put into the grooves of the ſame ſize, then move your pencil round at 1, and the pencil at 1 will deſcribe the true curve of an ellipſis.

FIG. 3. *An ellipſis being given, to find the centre and two axiſes.*

Draw any two parallel lines *a b* and *c d* at pleaſure, divide each of them in two equal parts at the points *e* and *f*, and through *e f* draw the line *k l*, divide *k l* into two equal parts at the point *g*, place the foot of the compaſs in *g*, with the other foot make two croſſes *h* and *i*, on the circumference draw a line *h i*, through *g* draw *m n* parallel to *h i*, alſo through *g* draw *o p* at right angles to *m n*; then *o p* is the tranſverſe axis, and *m n* the conjugate, and *g* the centre of the ellipſis.

FIG. 4. *How to proportionate one ellipſis within another; that is, to give it the ſame length in proportion to its width, as the length of the other has to its width.*

Let the given ellipſis be *a d b c*, make the parallelogram *e h g f*, to touch the ſides and ends of the ellipſis, draw the diagonals *e f*, and *g h*, of the parallelogram, let *r q* be the width of the leſſer ellipſis given, through the points *q*, or *r*, draw *l o*, or *m n*, parallel to the tranſverſe axis, at the points *m* and *n*, where it cuts the diagonal, draw *m l* and *n o*, parallel to the conjugate axis, will alſo ſhew its length.

FIG. 5. *How to deſcribe an ellipſis about a parallelogram, to have the ſame length in proportion to its width, as the length of the parallelogram has to its width.*

Let the given parallelogram be *a b c a*; let the diagonals *a c*, and *b d*, be drawn from the centre *i*; draw the quarter of a circle, 2 1 *k*, to half the width of the parallelogram; divide the quadrant into two equal parts at 1; through the point 1, draw the line *l* 3, parallel to the tranſverſe axis, to cut the diagonal *b d* in the point 3; then draw the lines 3 2, and 3 4: again, draw *f d*, parallel to 2 3, then *i f* will be half the width, and *d e* parallel to 3 4; and *i e* will be half the length of the ellipſis: make *i h* equal to *i e*, and *i g* equal to *i f*, which will give the four points through which the ellipſis muſt paſs; deſcribe the curve, and the thing will be done.

FIG. 6. *To divide a line in the ſame proportion as another is divided.*

D a, is a line given already divided, and *d e* is a line to be divided in the ſame proportion,

making

making any angle at *d* join *a e*, draw *b f* and *c g*, parallel to *a e*; then *d e*, is divided at *f* and *g*, as *a d* is at *b* and *c*.

FIG. 7. *To do the ſame by an equilateral triangle.*

A b is the given divided line, take *c d* the length as you would have divided; *d e* is the ſame length, and is divided in the ſame manner as *a b*.

FIG. 8. *To make an octagon the neareſt way in a ſquare.*

Draw the diagonal of the ſquare to croſs at *e*, fix the foot of your compaſs in *c*, and make an arch *f e g*; then ſet your gauge to *d f* or *b g*, which will gauge off each angle.

PLATE VII.

CONIC SECTIONS BY INTERSECTING LINES.

DEFINITIONS.

1. *A cone is a figure ſtanding upon a circular baſe, and diminiſhing to a point at the top.*

2. *If a cone is cut by a plane paſſing through its ſides, then the figure ſo cut is an ellipſis.*

3. *If a cone is cut by a plane parallel to one of its ſides, then the figure is a parabola.*

4. *If a cone is cut by any plane paſſing through the oppoſite cone, then the figure is an hyperbola.*

To deſcribe the ellipſis from the cone.

FIGURE A. Let *B* be half the circle of the baſe of the cone, *n* the vertex at the top; then *n a* and *n d* are two ſides; let the cone be cut by a plane paſſing through *g h*; biſect *g h* at the point *k*, and through *k* draw *r q*, parallel to the baſe *a d*; alſo biſect *r q* in *m*, deſcribe the ſemicircle *r p q*, draw *k p* at right angles to *q r*; then is *g h* the length of the ellipſis, and *h k* half its width; then the *figure* may be deſcribed at *C*, which is explained in the next plate.

To deſcribe the parabola from the cone.

FIGURE A. Let *i e* be the axis of the parabola, parallel to the other ſide *n d* of the cone, and through *e* draw *e c* at right angles to the baſe; then will *e c* be half the width of the parabola, and *e i* its height; then the *figure* will be deſcribed, as at *D*, by interſecting lines upon each ordinate, up to the crown, from the equal diviſions on each ſide.

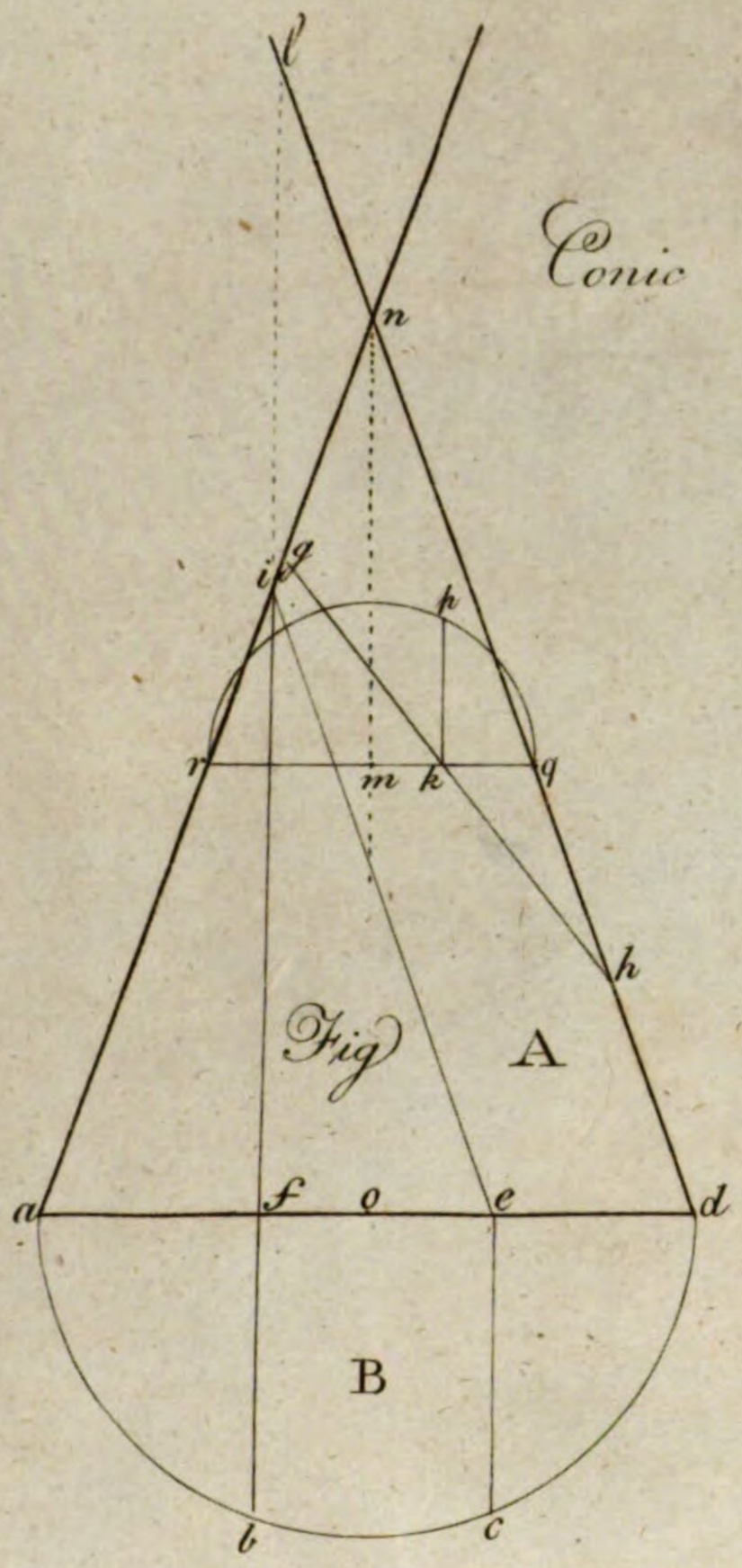
To deſcribe the hyperbola from the cone.

FIGURE A. Let the axis of the hyperbola be *i f*, cut by a plane paſſing through *f* and *i*, till it cut the oppoſite cone at *l*; draw *f b* at right angles to *a b*, then is *f i* the height of

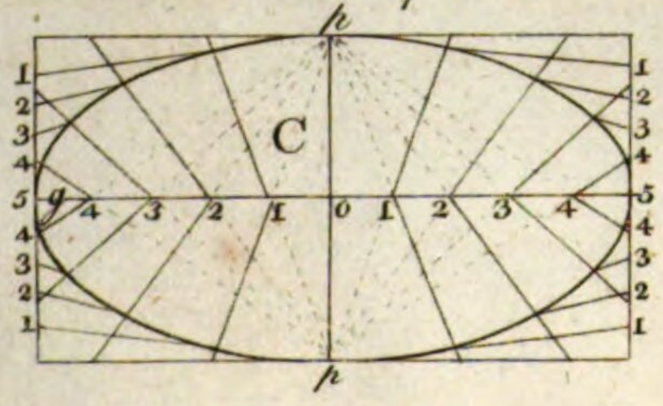
an

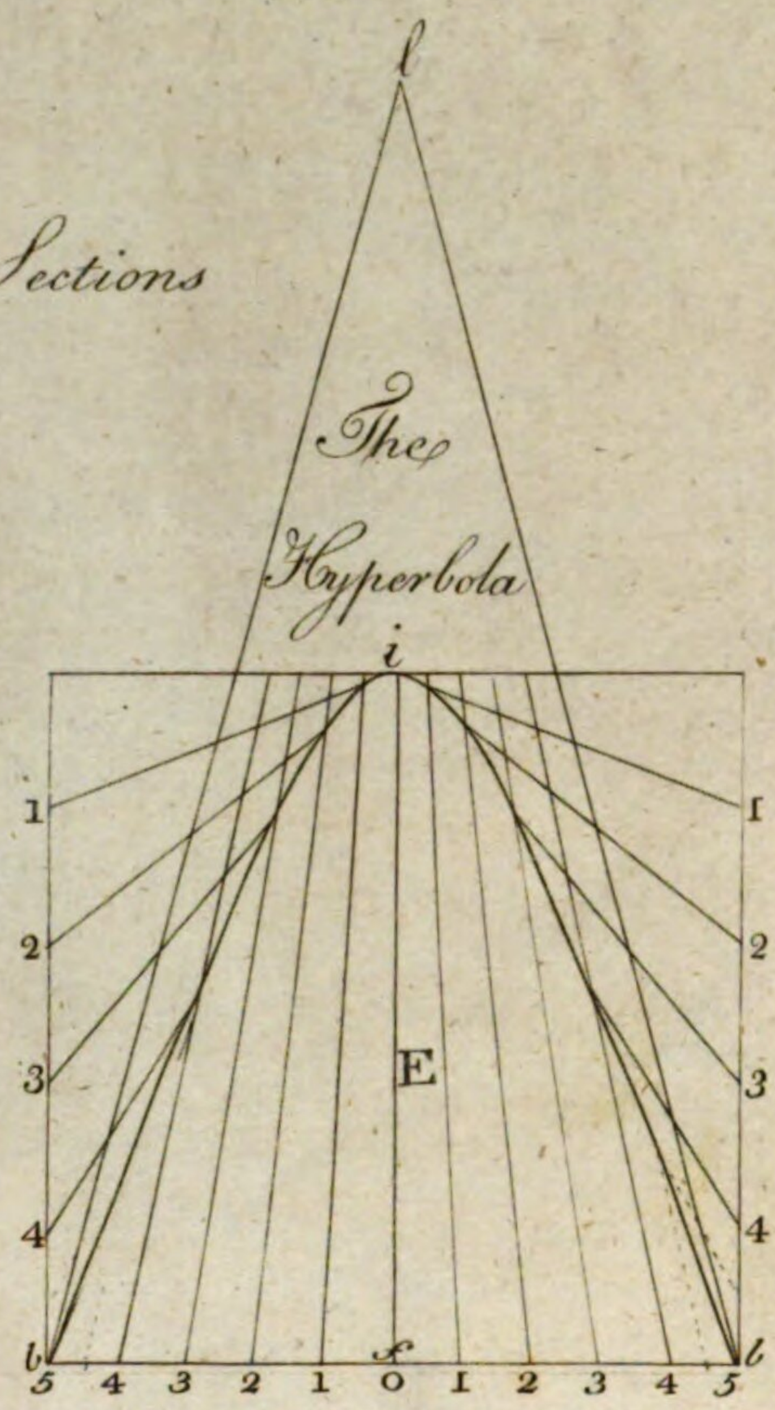
Plate 7

Conic Sections



The Ellipsis





The Parabola

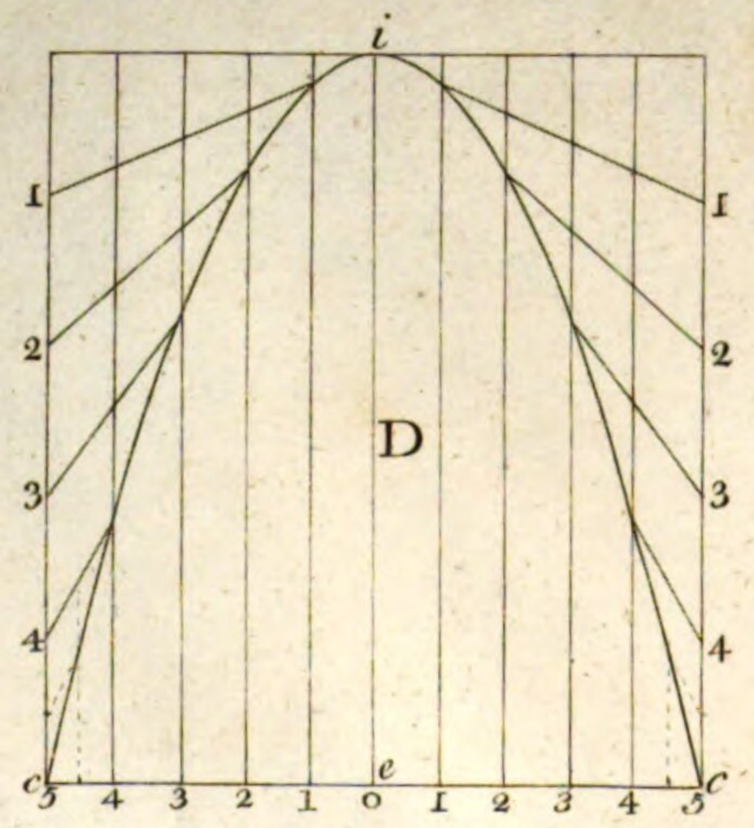


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Plate 8

Fig A

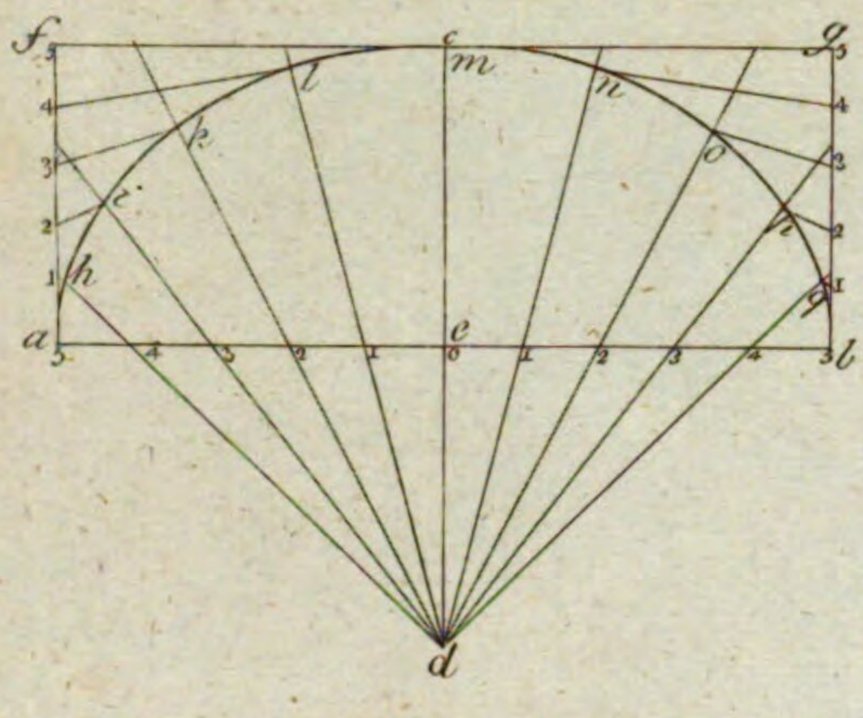


Fig B

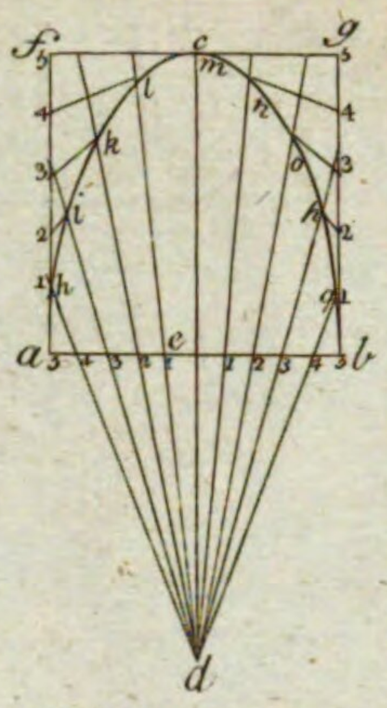


Fig C

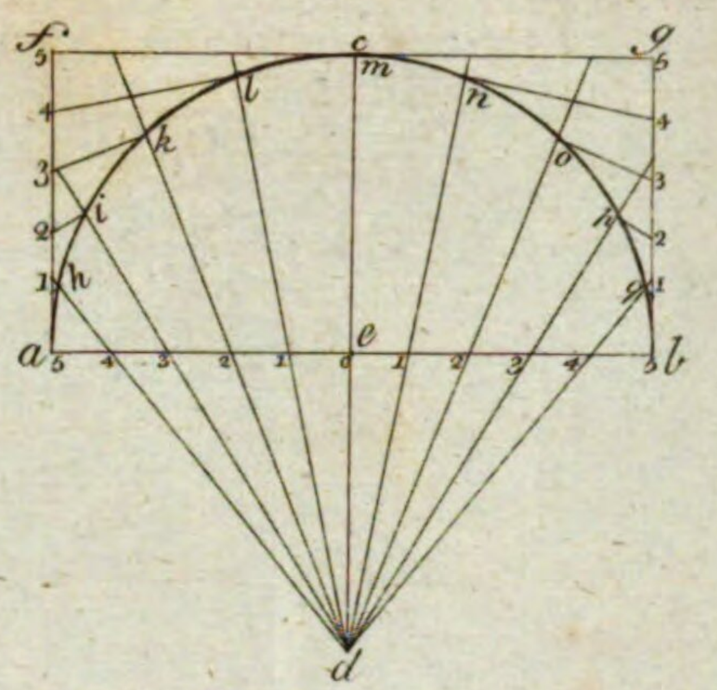


Fig D

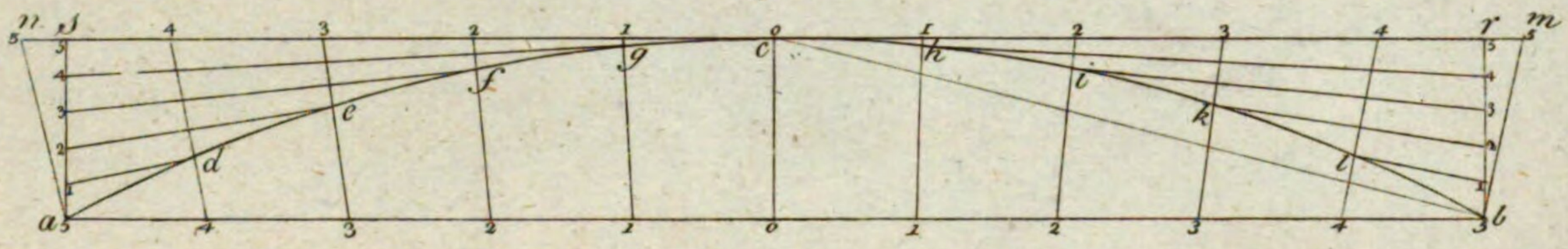


Fig E

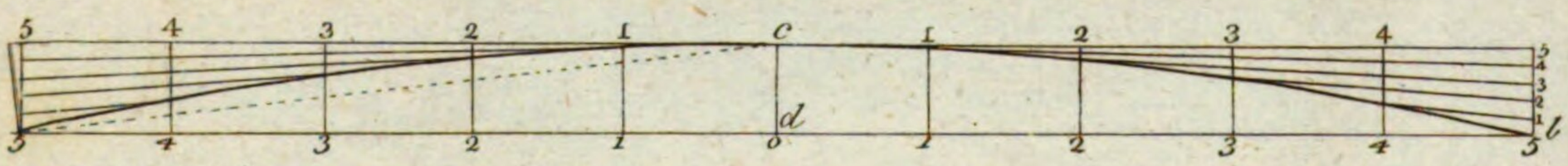


Fig. F.

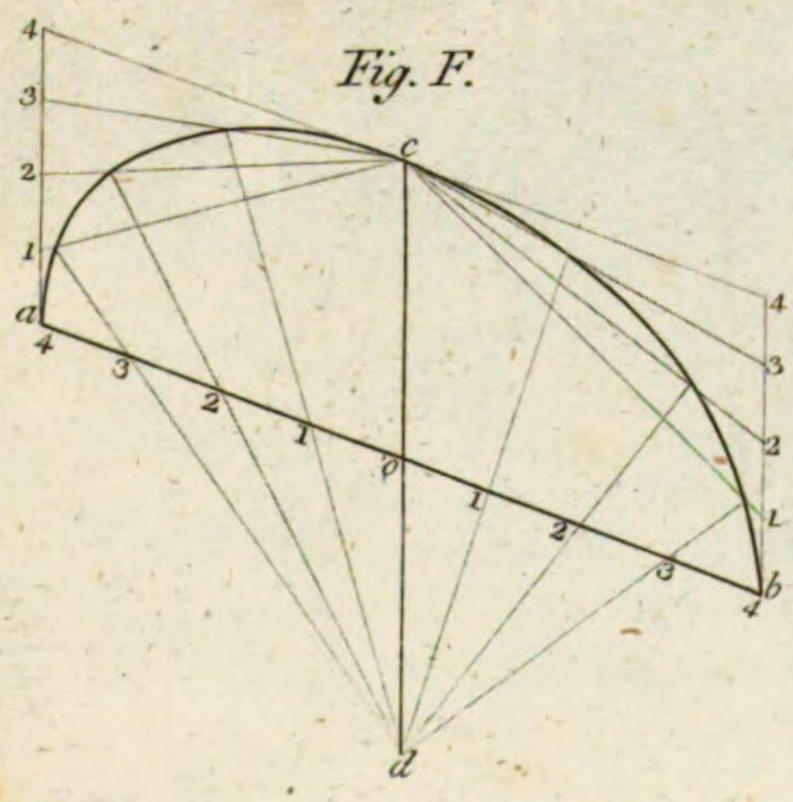


Fig. G

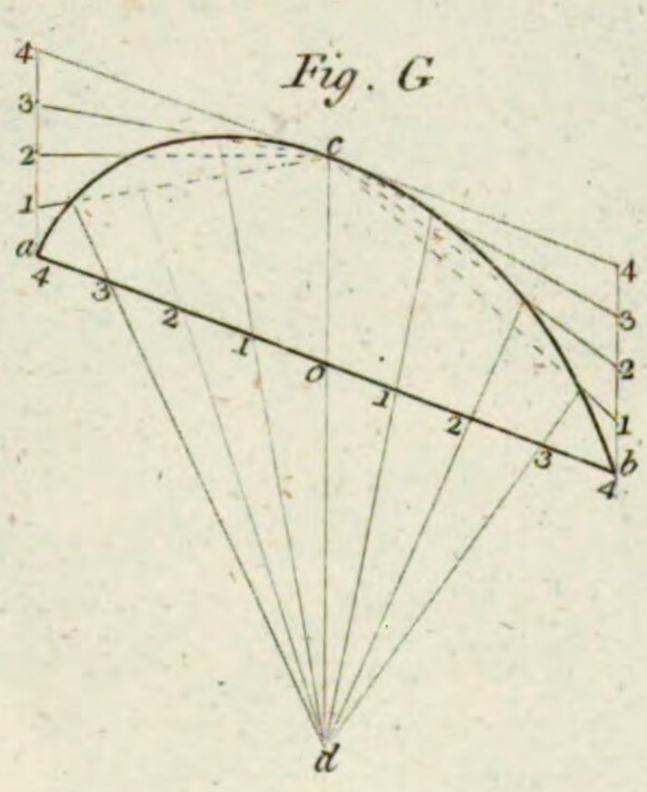
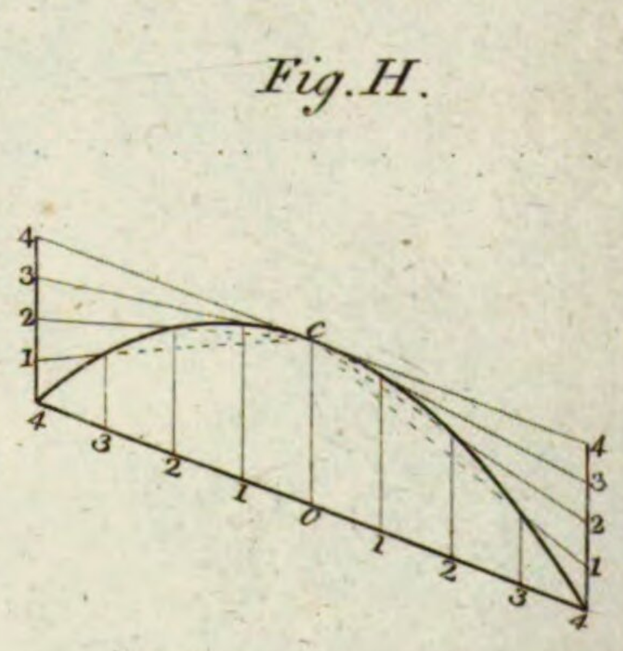


Fig. H.



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an hyperbola, and *f b* half the width of the baſe, and *i l* its tranſverſe axis; then make *f i* at *E* equal to *f i* in *figure A*, make *i l* in *E* equal to *i l* in *figure A*, *b b* in *E* equal to twice *f b* in *figure A*; let the baſe *b b* in *E* be divided into ten equal parts, as at 0 1 2 3 4 5, *that is*, into five equal parts on each ſide from the centre, and draw lines to the point *l* through theſe points; likewiſe divide the height into five each way, and draw lines to the crown at *i*; this will ſhew the points through which the curve muſt paſs.

PLATE VIII.

How to draw any ſemi-ellipſis upon the tranſverſe, or conjugate axis, or even a ſemicircle itſelf, by a new method of interſecting lines.

FIGURES A and B. Let the given axis be *a b*, and let it be divided into any number of parts, as 10; alſo let the height be divided into half the number of parts; make *e d* equal *e c*, *that is*, to the height of the arch; then, from the point *d*, draw lines through the equal diviſions of the axis *a b*; likewiſe, through the points 1 2 3 4 5, in the height *a f*, draw lines tending to the crown at *c*, which will interſect at the points *h i k l*; and lines being drawn through the diviſions of *b g* to *c*, at the crown, in the ſame manner, will give the points *n o p q*; a curve being traced through theſe points, will ſhew the true curve of an ellipſis.

The ſemicircle, *figure* C, is drawn in the ſame manner, by making *a f* equal to one half of *a b*.

How to draw the true ſegment of a circle, by the method of interſecting lines.

FIGURE D. Let *a b* be the length of the ſegment, and *o c* its height, and draw the chord *b c* for one half of the ſegment, and draw *b m* at right angles to *b c*; and from the centre at *o*, divide the diameter *a b*, each way, into five equal parts; alſo from *c*, at the crown, in the centre of the line *m n*, divide *c m*, and *c n*, each into five equal parts; and draw 1 1, 2 2, 3 3, 4 4, 5 5, on each ſide, through the diviſions 1 2 3 4 5 on *a s*, and 1 2 3 4 5 on *b r*; draw lines to the crown at *c*, which will interſect the other lines at the points *d e f g*, and *h i k l*: the curve being traced, the thing is done.

How to draw a flat ſegment of a circle nearly true.

Divide the length of the ſegment into equal parts each way, from the centre *d*, as before, and draw the lines 1 1, 2 2, 3 3, 4 4, 5 5, all at right angles, to the length *a b*; lines being drawn to the crown at *c*, from the diviſions at each end, will ſhew the points which the ſegment muſt paſs through; the curve being traced, the thing is done.

Remark. Although this laſt method is not the true ſegment of a circle, but a parabolic curve, yet it will be found uſeful in practice, in tracing any ſegment whoſe height is not more than one tenth part of its length; and if the centre of the ſegment is found, and drawn with a compaſs, the difference will hardly be ſeen, and the flatter the ſegment is, this difference will become the more imperceptible; but if the height exceeds one tenth of

its length, the difference will be viſible; for then the arch will be quicker at the crown, and get flatter and flatter towards each extreme.

In the ſame manner may all kinds of rampant ellipſes be deſcribed, or any ſegment of them, as at *F* and *G*, alſo a rampant parabola in the ſame manner as at *H*.

PLATE IX.

THE SECTIONS OF A CYLINDER.

DEFINITION.

A cylinder is a figure generated by the revolution of a right angled parallelogram about one of its ſides; conſequently the ends of the cylinder are equal circles, and the line paſſing through the centre of the cylinder, is called the axis.

The ſection of a cylinder, cut by any plane, is an ellipſis. This is evident to the meaneſt conception; but for a farther ſatisfaction, it is proved by the writers of conic ſections.

To find the ſection of a ſemi-cylinder, by ordinates, when it is cut at right angles to the plane, paſſing through its axis, in the direction a b. FIG. 1.

Let the circle of the baſe be divided into equal parts at *B*, and drawn parallel up the cylinder to the line *a b*, at the points 0 1 2 3 4 5, &c. and from theſe points draw lines at right angles to *a b*; then *B* being pricked from *A*, as the figures direct, *B* will be the ſection of the cylinder.

DEMONSTRATION.

Conceive the circle *A* at the baſe to be turned at right angles to the plane, alſo the ellipſis *B* at right angles to the ſame plane; then will the ordinates of *B* be parallel and perpendicular over the ordinates of *A*, and every correſponding point in the circumference of *B* will fall perpendicular to the ſame correſponding points in *A*: therefore *B* is the true ſection of the cylinder, cut in this poſition.

To cut a cylinder in the direction a b, *upon a plane, paſſing through its axis, to make an acute angle with that plane.* FIG. 2.

Let *C*, at No. 1, be the given angle, which the ſection at *B* is to make with the plane of the cylinder; take *a b* in *figure* 2, *that is*, the radius of the baſe, and ſet it from *b c*, at No. 1, perpendicular to *i b*; draw *c c* parallel to *i b*, alſo from *c* draw *c e* perpendicular to *i b*; then take the diſtance *c i*, ſet it from *i* to *f*, in *figure* 2, at *B*; likewiſe take *i e* from No. 1, and ſet it from *i* to *e* in *figure* 2, at *B*; draw *e d* parallel to *m n*, in the baſe, to cut the rake in *d*, and join *d f*; then is *d f* the bevel of the firſt ordinate of the ſection *B*. And draw the lines *e c* and *d a* parallel to the axis; join *a c* at *A*; then will *a c* be the bevel of the firſt ordinate of the baſe. Then draw all the other ordinates of *A* parallel to *a c*, and at the points 1 2 3 4, &c. in *m n*, draw lines parallel to the axis of the cylinder, to cut the raking line 1 2 3 4 5, &c. From theſe points, let lines be drawn parallel

Plate 9

Fig 1

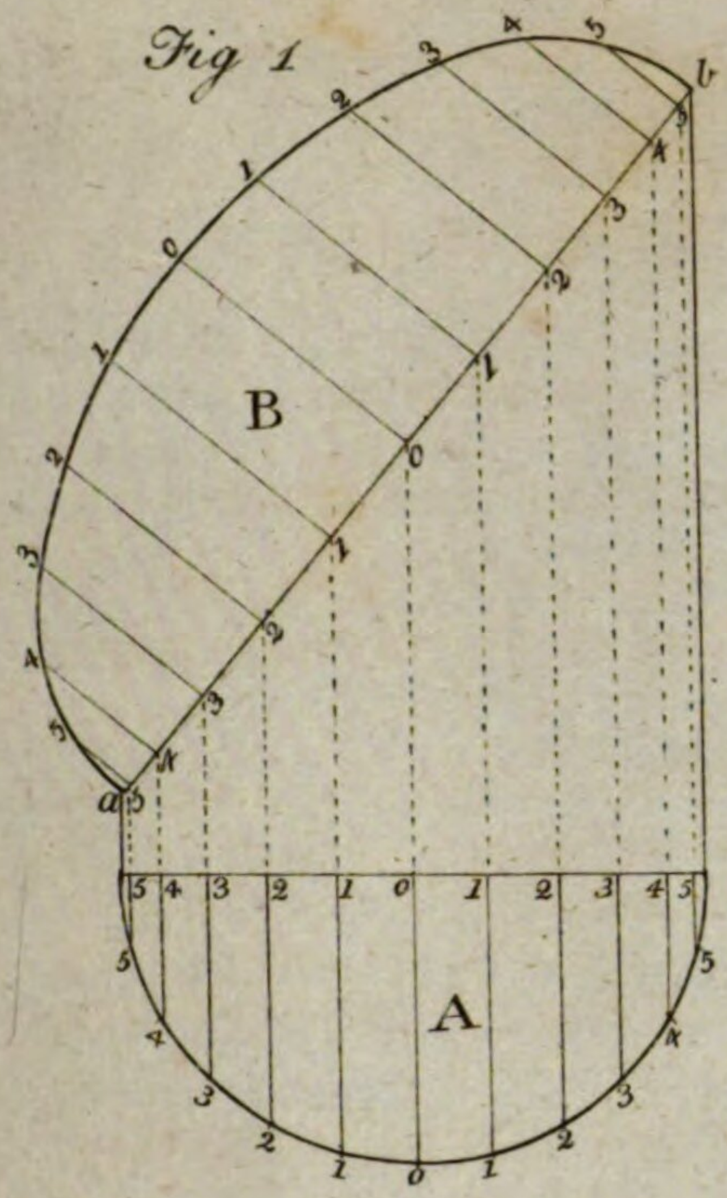
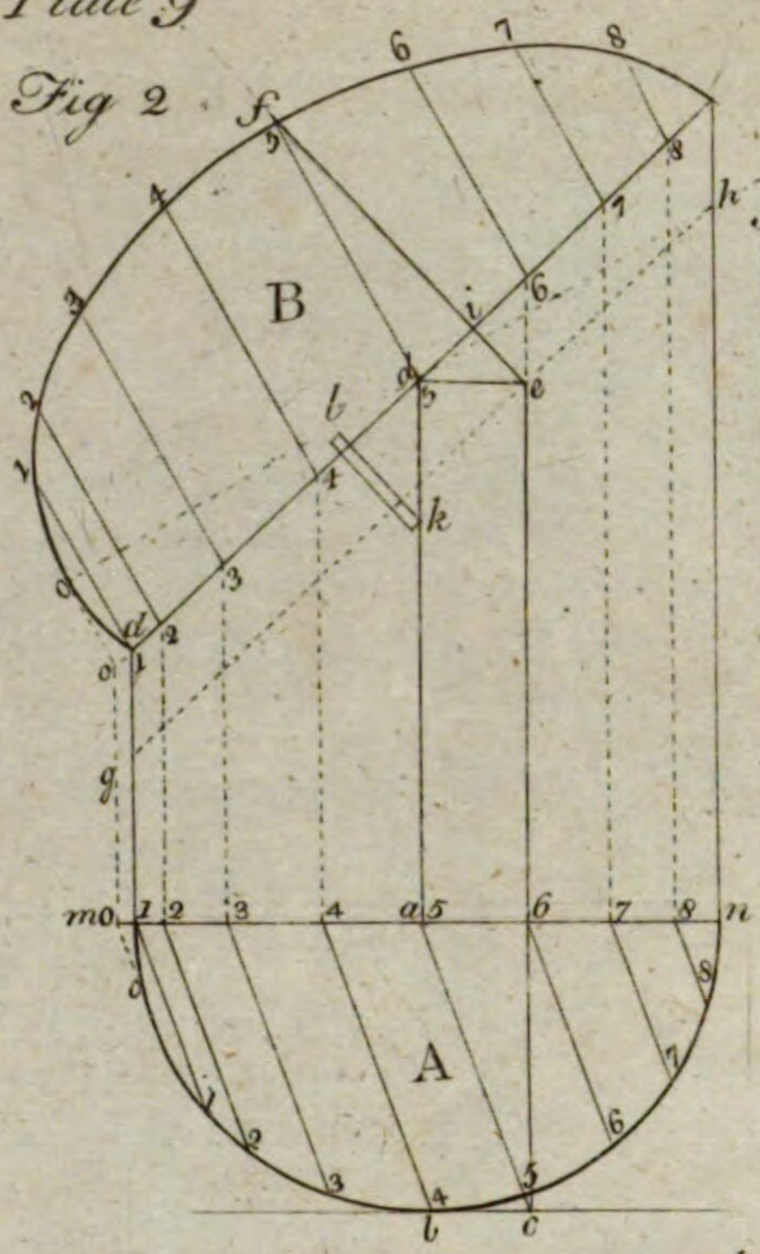


Fig 2



N°1 Fig 2

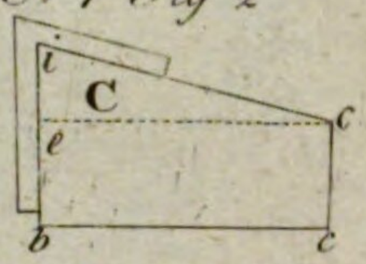
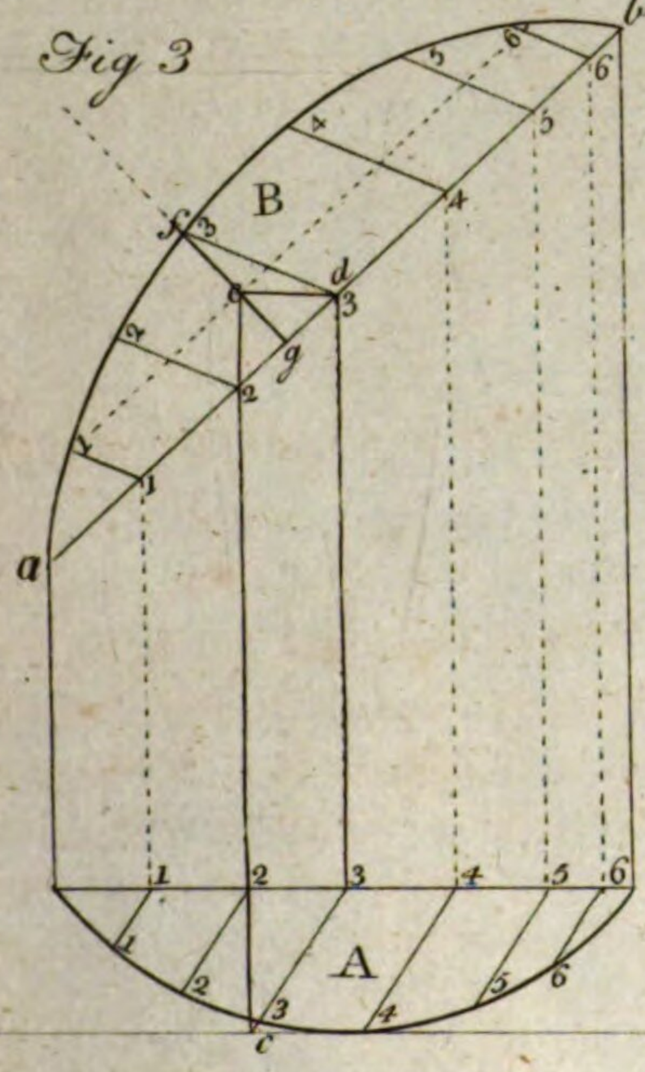


Fig 3



N°1 Fig 3

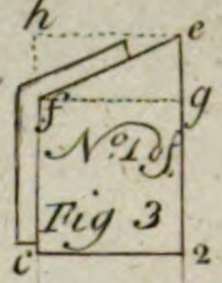
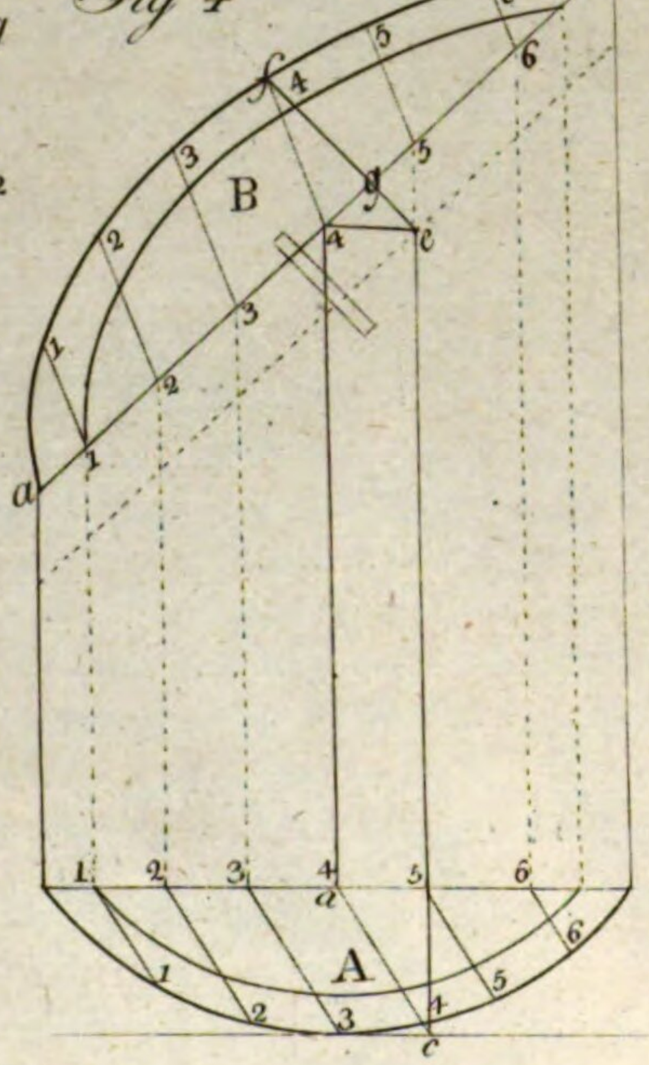
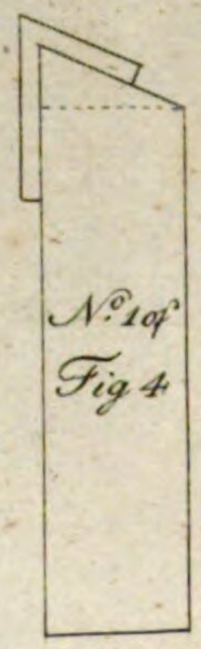


Fig 4



N°1 of Fig 4



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to *d f*; then the ordinates of *B*, being pricked from the ſame correſponding ordinates of the baſe at *A*, will give the ſection of the cylinder.

Note. The point *f* will fall beyond the ſweep at the ſection *B*.

DEMONSTRATION.

Since *i f* is equal to *i c*, let the plane *B* be conceived to be turned round the line *a b* to make an angle at *i*, with the line *i e*, equal to *e i c*, at No. 1; then the point *f* will be perpendicular to the point *e*, and the line joining *e* and *f*, will be equal to *e c*, at No. 1. But *e c* is equal to 6 *c* at *A* upon the baſe; therefore the point *f*, when oppoſite to *e*, will be perpendicular over the point *c*, in the baſe: conſequently the line *d f*, will be perpendicular, and parallel over the line joining *a c*; becauſe all the ordinates in *B* are drawn parallel to *d f*, and perpendicular to every correſponding ordinate in the baſe, which are parallel to *a c*; and as all the ordinates of *B* are equal to their correſponding ordinates in *A*, ſo they are alſo parallel and perpendicular to them; conſequently every point in the circumference of *B*, will be over the ſame correſponding points in the baſe; therefore *B* is the true ſection of the cylinder, cut in this poſition, which was to be demonſtrated.

To cut a ſegment of a cylinder, in the direction a b, *to make an obtuſe angle with the plane of the ſegment.* FIG. 3.

Let No. 1 be the angle given, which the ſection *B* is to make, with the plane of the ſegment; from *f* in No. 1, draw *f g* at right angles to *f c*, and *g e* alſo perpendicular, to make the right angled triangle *e g f*. And in *figure* 3, at *B*, draw *g f*, at right angles to *a b*, and make *g e* equal to *g e* at No. 1. Alſo, make *g f* at *B* equal to *e f* at No. 1. Draw *e d* at *B*, parallel to *m n* at *A*, the baſe, and at the point *d*, where it interſects the line *a b*, join *d f*; then *d f* is one of the ordinates. From *e* and *d*, draw the two parallel lines *e c*, and *d* 3, join *c* 3; then *c* 3 will alſo be an ordinate of the baſe. Draw parallel lines at diſcretion to *c* 3, for the other ordinates of the baſe; and from their interſection upon *m n*, draw lines parallel upon the cylinder, to cut *a b* in 1 2 3 4, &c. and from theſe points, draw parallel lines to *d f*, which are the ordinates of *B*: theſe, being pricked from the baſe as the figures direct, will give the points through which the curve muſt paſs, which being traced, will be the true ſection of the ſegment of the cylinder.

DEMONSTRATION.

Let the ſection *B* be turned round the line *a b*, to make an angle with the plane of the ſegment equal to No. 1; then, *g f* at *B* being equal to *e f* at No. 1, and *e g* at *B* equal to *e g* at No. 1, therefore a line joining *e* and *f* at *B* is equal to *f g*, or *e h* at No. 1, *that is*, equal to 2 *c*, the width of the baſe *A*; but *e f* is alſo parallel and perpendicular over 2 *c*, therefore the point *f* will be perpendicular to the point *c* in the baſe: but the point *d* is level with the point *e*, *that is to ſay*, *e d* is parallel to *m n*; and the point *f* becomes alſo level with the point *e*, when turned round; therefore the line joining *f* and *d*, will be parallel to the baſe, and perpendicular over 3 *c*: for *d* is perpendicular to 3, and *f* is perpendicular over *c*; conſequently *d f* is an ordinate of the ſection, and 3 *c* an ordinate of the baſe: but all the ordinates parallel to *d f*, are reſpectively equal and perpendicular over thoſe of *A*, which are parallel to 3 *c*; therefore they are in the true curve of the ſection *B*, which was to be demonſtrated.

That the Reader may perceive this more clear, the beſt way is to draw thoſe lines on paſteboard, the ſection and the end being made to turn round, in their proper poſition; then the demonſtration will be clearly ſeen.

FIGURE 4, is to be laid down and demonſtrated in the ſame manner as FIGURE 2.

Remark,

Remark. Upon theſe figures depend the whole principles of hand rails for ſtairs: the Reader ought to underſtand how to form the ſection of a cylinder, in any caſe whatever; for the face or raking mould of a hand rail is nothing but the double ſection of a cylinder, as in *figure* 4, at *B*, where the double circle upon the baſe *A* repreſents the plan of a rail, and the bevel at No. 1, *figure* 4, repreſents the ſpring of the plank, and *a b* the pitch of the rail: therefore, it is very neceſſary that the Reader ought to have a knowledge of theſe figures and their demonſtrations; and not to be ſatisfied with only doing of it, but to read theſe demonſtrations, and conſider them with attention; then he will be able to ſee the reaſon why every line is drawn in the manner it is.

PLATE X.

THE SECTIONS OF A GLOBE, OR ANY OTHER FIGURE STANDING UPON A CIRCULAR BASE; ALSO, THE SECTION OF ANY FIGURE STANDING ON AN IRREGULAR BASE.

DEFINITION.

A globe is a figure generated by the revolution of a ſemicircle round its diameter, which becomes the axis of the globe.

AXIOMS; OR, SELF-EVIDENT TRUTHS.

1ſt. *From this definition it appears, that every plane ſection paſſing through the centre, is equal to one another.*

2d. *Every ſection of a globe, cut by a plane, is a circle; for the generating circle may be made to revolve round any line, as an axis; and therefore every point in it will generate a circle, whoſe diameter muſt be twice the radius of that circle, diſtant from the axis of the globe.*

3d. *If a ſemi-globe is cut by a plane at right angles to the plane of its baſe, the ſection will be a ſemicircle.*

To find the ſection of a ſemi-globe cut by a plane at right angles to the plane of its baſe. FIG. 1.

It appears from the laſt axiom, that there is no tracing required: for, let the ſection be cut acroſs *a b*, *figure* 1; divide *a b* in two equal parts at the point *c*; and on *c*, as a centre with the radius, *c a*, or *c b*, deſcribe the ſemicircle *A*, which is the true ſection required.

The ſame by ordinates. FIG. 2.

Draw any line *d e* through its centre, and let *a b* be the place of the ſection upon the baſe, as before; place the foot of your compaſs in the centre of the globe at *f*, and, with a radius *f c*, draw an arch from *c*, round to *g*, in the diameter *d e*; the foot of your compaſs remaining ſtill in *f*, draw the concentric dotted circles from *c b* to *f e*, and at the interſecting points

Plate 10

Fig 1

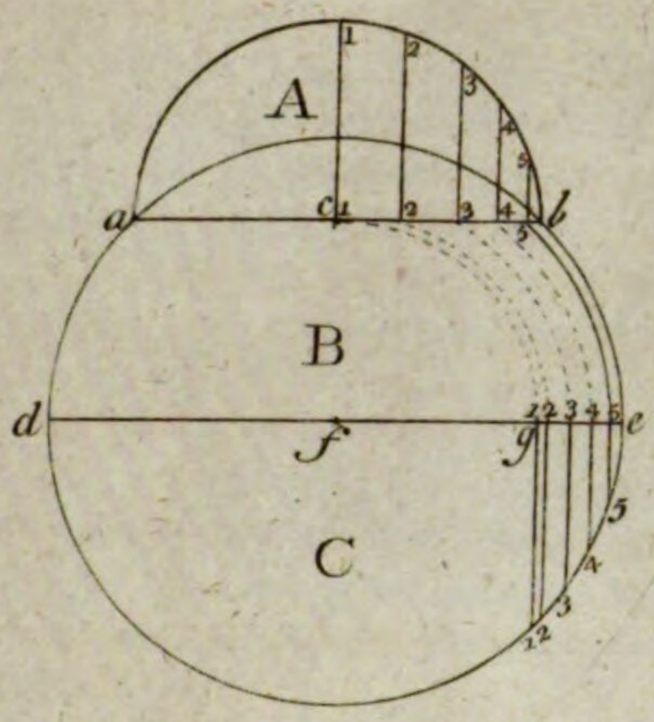


Fig 2

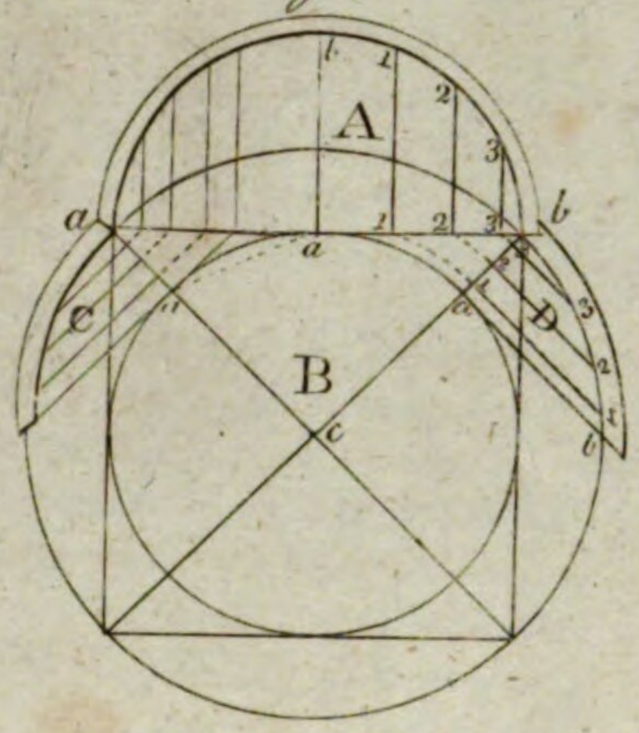


Fig 3

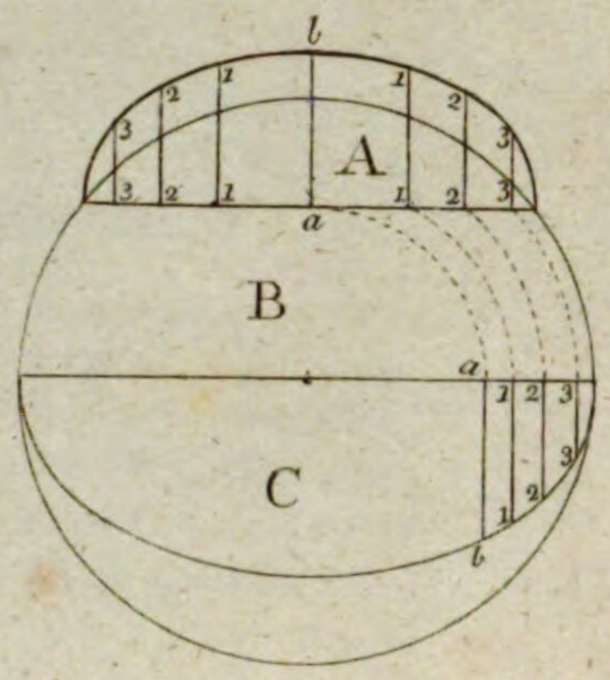


Fig 4

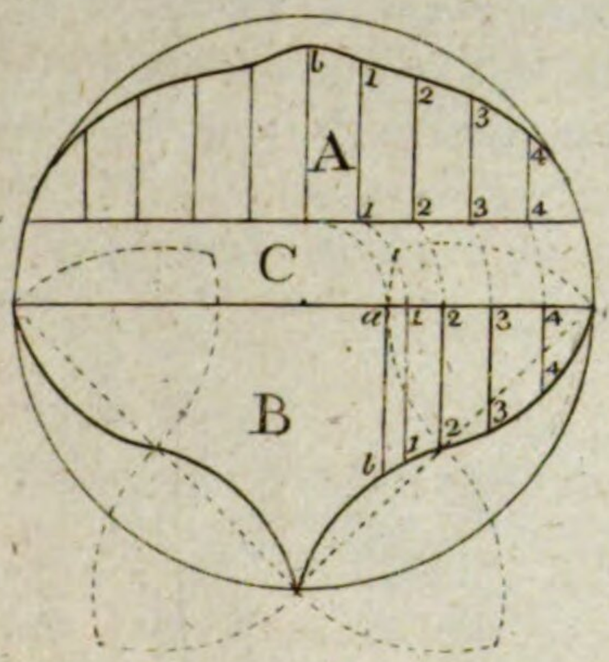
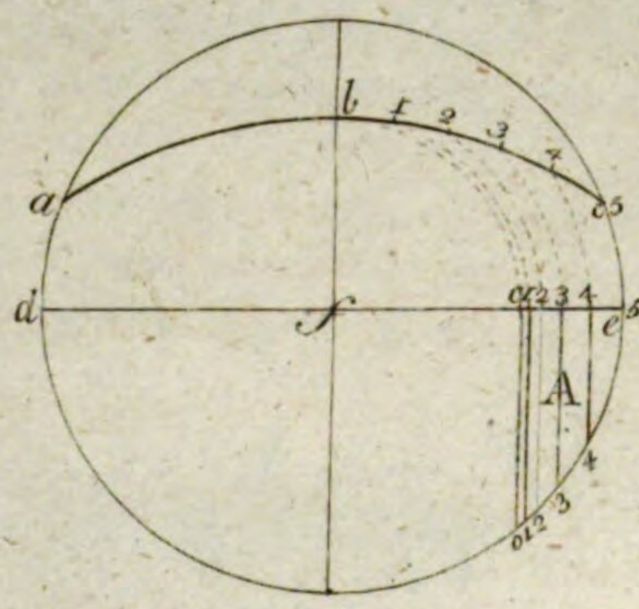


Fig 5



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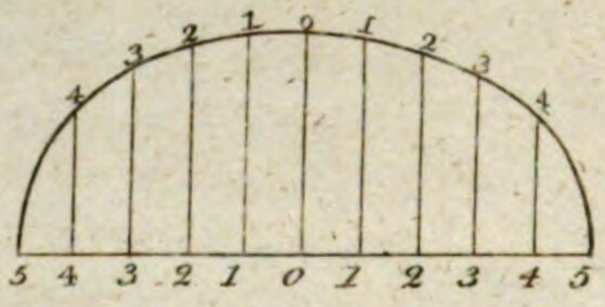

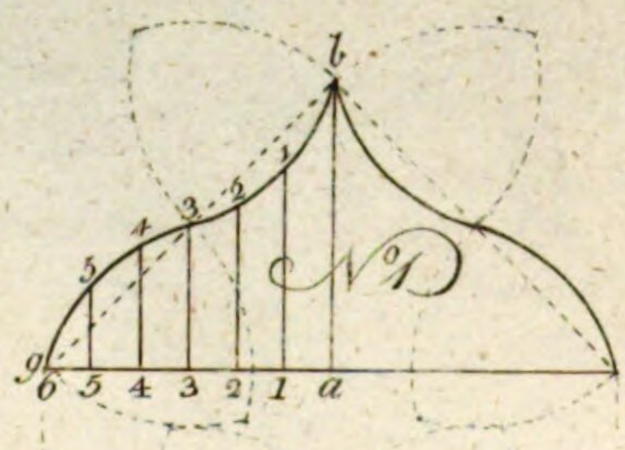

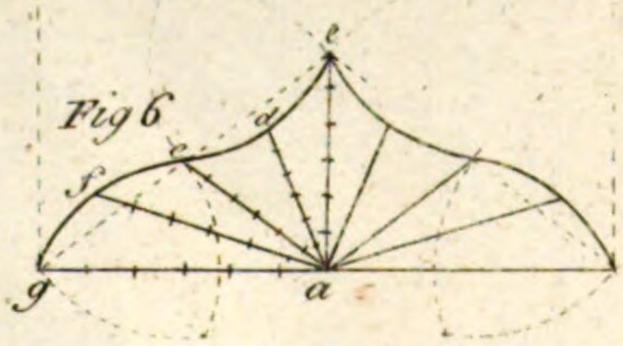

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points 1 2 3 4 5 in *f e*, and likewiſe in *c b*, erect perpendiculars to thoſe lines; then *A* being pricked from *C*, as the figures direct, will give the points through which this ſemicircle muſt paſs.

DEMONSTRATION.

Conceive the ſemicircle *C* to ſtand at right angles upon *d e*, alſo the ſection *A* to be at right angles to *a b*; now it is evident, if *g i* is the height of the globe over the point *g* in the baſe, *c* 1, which is equal to *g* 1, muſt alſo be the height of the ſection, becauſe the points *c* and *g* ſtand at an equal diſtance from the centre; and therefore the point 1 over *c*, is in the ſurface of the globe. In the ſame manner it may be proved, that any other points carried round by the dotted lines are in the ſame ſurface; but the ſection that ſtands upon *a b*, in *A*, is a ſemicircle; and conſequently the method of tracing is alſo a ſemicircle.

Obſervation. Hence appears the erroneous principle of tracing uſed by a late writer upon this ſubject, as you may ſee at *figure* 2, where *A* is the ſection of a globe, and the bracket at *D* is the ſection acroſs the diameter. *A* is truly traced from *D*, becauſe the ordinates are carried round in circles; but by his method of tracing, as you ſee at *C*, upon the other ſide, the point of the bracket *C* falls within the ſweep of the circle, by reaſon of the ordinates of *C* being carried ſtraight through between the two baſes, which I have proved to be falſe. And this he has applied in bracketing up the angles in the ſquare well-hole of a ſtaircaſe, to the circular curb of a ſkylight, which, if truly done, is nothing elſe but upon the ſame principle as the ſections of a globe.

FIGURE 3, is done upon the ſame principle as *figure* 1. *A* is the ſection traced from *C*, and wants no other demonſtration than what has been given in *figure* 1.

FIGURE 4, is an ogee ſection, ſtanding upon a circular baſe acroſs the diameter; and *A* is the ſection traced from it, upon the ſame principle as *figure* 1.

From theſe examples it is clear that this method of tracing does not depend on the form of the top, but entirely upon the baſe. Theſe figures are ſuppoſed to be generated round an axis; and, as every circle is carried round at an equal diſtance from the axis, the perpendicular height of the figure, upon any circle, muſt be the ſame height in every point throughout that circle; which proves itſelf to be the only method for any thing of this kind.

A ſemi-globe being cut by a cylindrical ſurface perpendicular to the plane of its baſe, to find the form of a veneer that will bend round it. FIG. 5.

Let *d e* be drawn through the centre *f*; and place the foot of your compaſs in *f*, the centre; and from the points *b* 1 2 3 4, which are equally divided from the centre at *b* in the circular ſurface, draw the concentric dotted lines round to the diameter *d e*, at 0 1 2 3 4, and at theſe points raiſe the perpendiculars 0 0, 1 1, 2 2, 3 3, 4 4. Take the ſtretchout round *b* 1 2 3 4 5, which is one half; and lay it upon the baſe of No. 1 each way, from 0 1 2 3 4, &c. and No. 1 being pricked from *A*, *figure* 5, as the figures direct, will give the points through which the curve muſt paſs for the veneer.

DEMONSTRATION.

For, ſince the ſection ſtanding upon *d e* is a ſemicircle, which is equal to the ſemicircle upon the baſe; and as the points 1 2 3 4 in the circular ſurface, ſtand at the ſame diſtance from the centre *f*, as 0 1 2 3 4, in *d e*; now if the point *o* at No. 1, is made to coincide with the point *b* in *figure* 5, then the height *o o*, ſtanding over the point *b*, will be equal to the height *o o* at *A*; but theſe points are at an equal diſtance from the centre, therefore the top of each ordinate will be in the ſurface of the globe. In the ſame manner every other point may be proved, when bent round and elevated, to be of the ſame height, and at an equal diſtance from the centre with thoſe of *A*; and therefore No. 1 is the true form of the veneer.

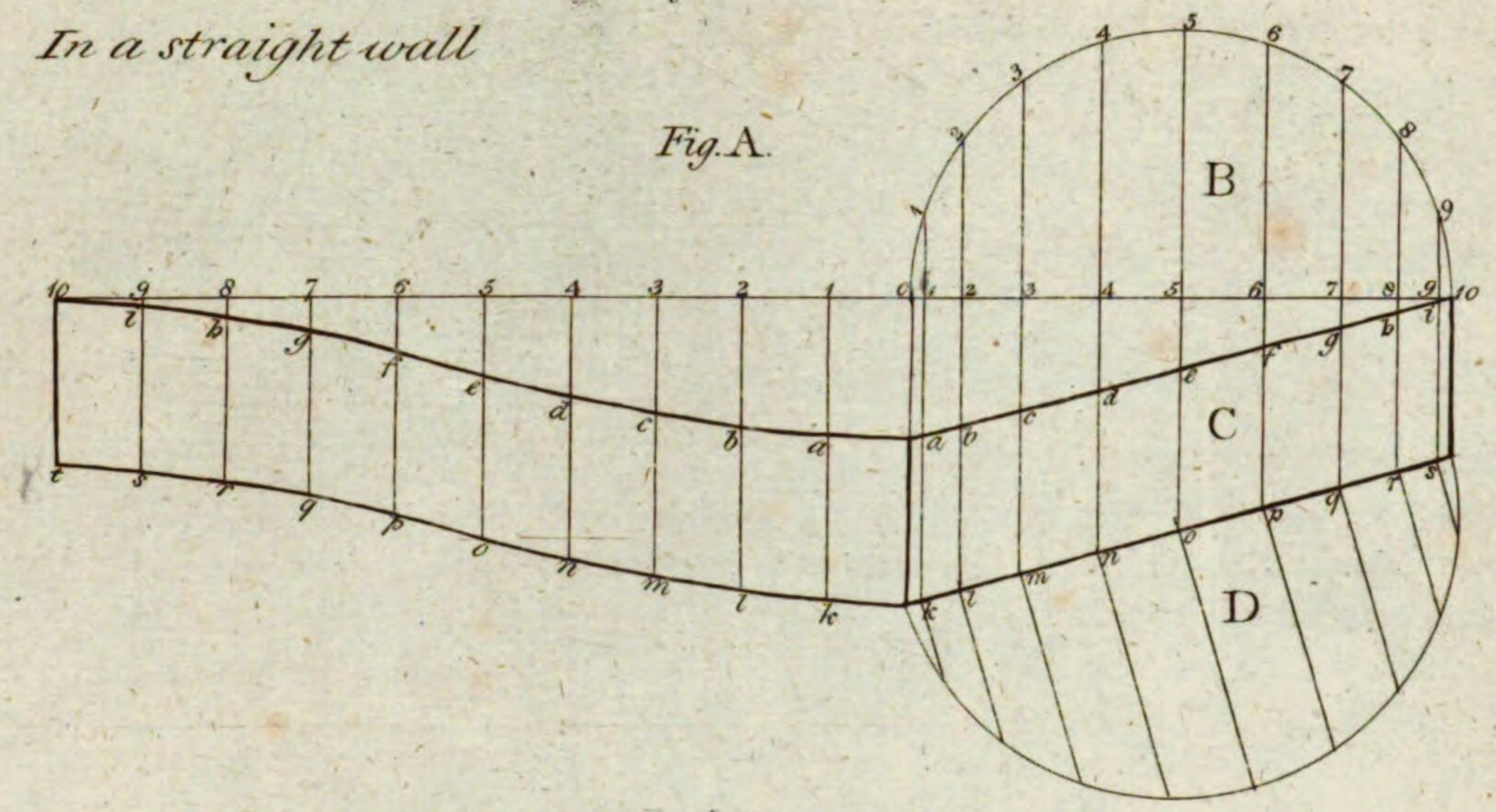
To find the ribs of a gothic niche, being the plan, and No. 1 *the front elevation.* FIG. 6.

Take the length of each baſe upon the plan, and make them the baſes of No. 2, No. 3, No. 4, and No. 5; divide each baſe into five equal parts; alſo divide the half of No. 1 into ſix parts, and draw the ordinates from the equal diviſions, perpendicular to each baſe; then prick each from No. 1, as the figures direct, will give the form of each rib. This wants no demonſtration.

Plate 11

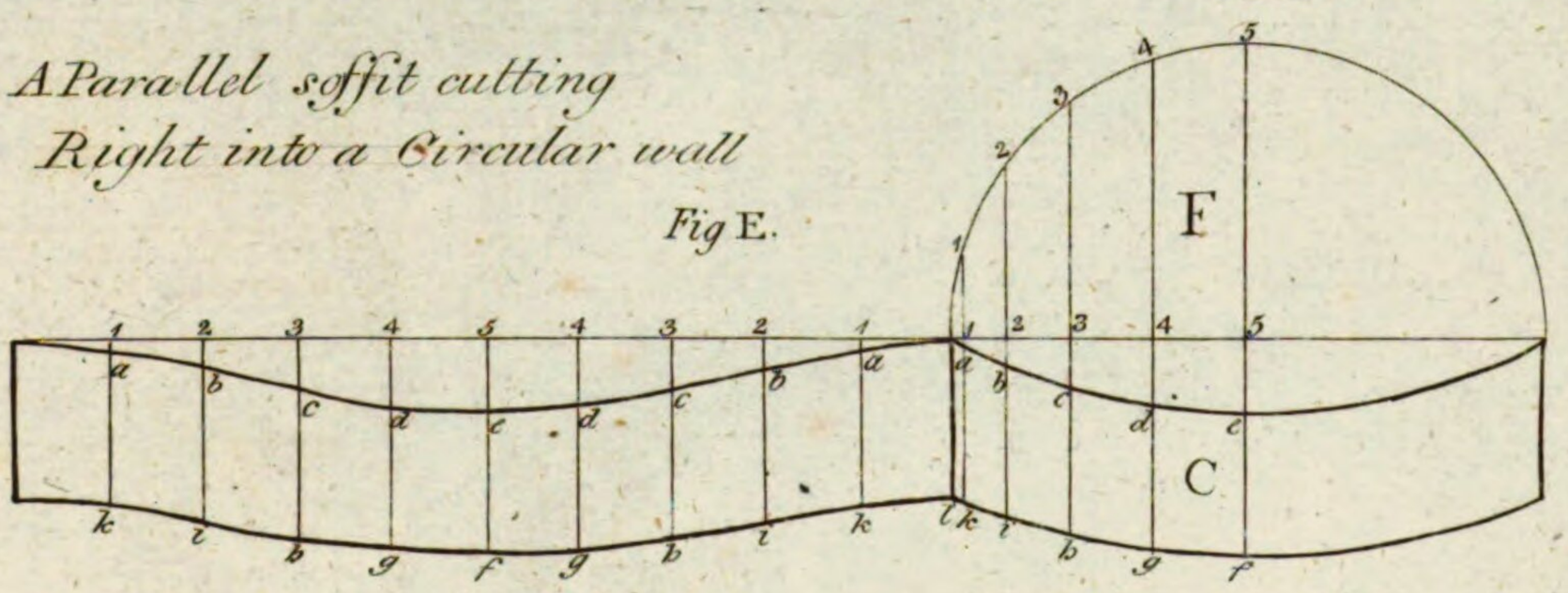
A Parallel soffit cutting oblique
In a straight wall

Fig. A.



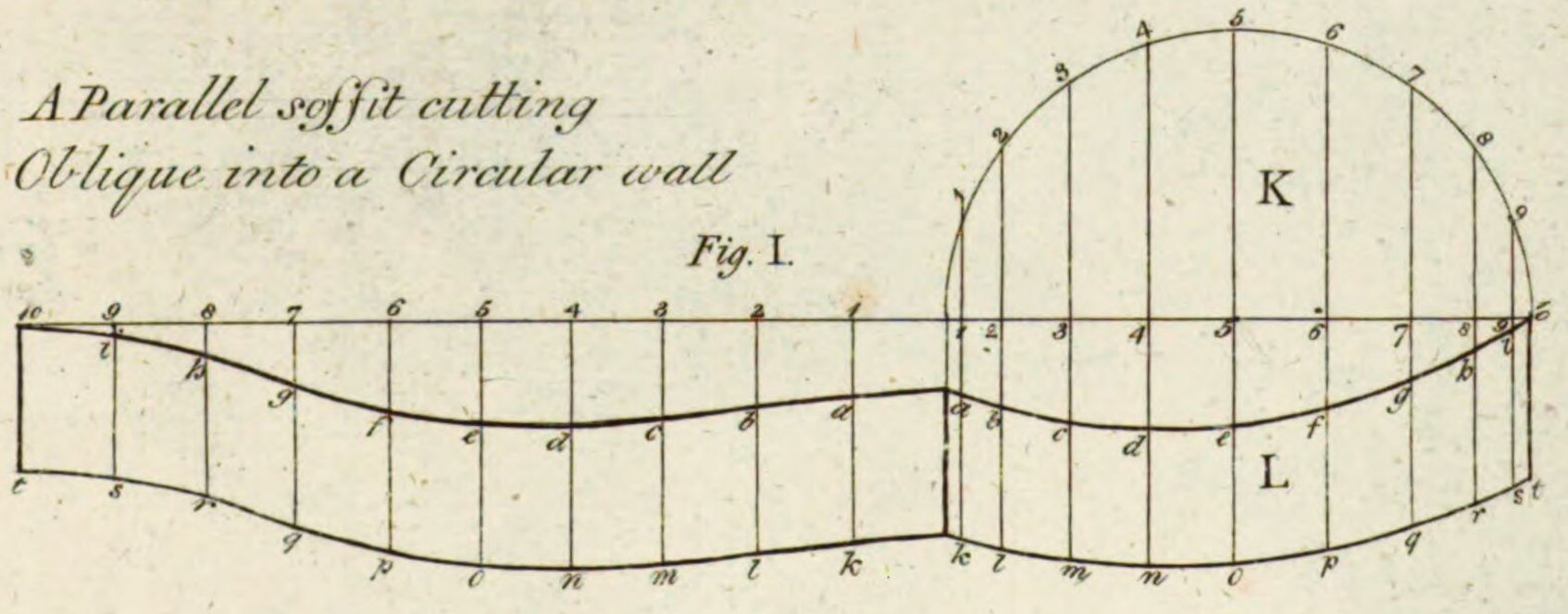
A Parallel soffit cutting
Right into a Circular wall

Fig E.



A Parallel soffit cutting
Oblique into a Circular wall

Fig. I.



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THE

THEORY AND PRACTICE

OF

CARPENTRY.

PLATE XI.

DEFINITION.

A ſoffit, in the Theory of Carpentry, ſignifies the covering of any ſurface whatever, ſpread out on a plane if poſſible.

How to ſtretch out a ſoffit, when a window or door, having a ſemicircular head, cuts into a ſtraight wall, in an oblique direction.

Let *C* be the plan or opening of the window, in *fig. A*, and let the baſe of the ſemicircle *B* be drawn at right angles to the jambs, or ſides of the plan *C*; divide the ſemicircle into any number of equal parts, as ten, and draw the ordinates acroſs the plan *C*, then ſtretch the diviſions round *B*, along the ſoffit, in the ſame ſtraight line with the baſe of *B*; under *fig. A*, the ordinates being drawn acroſs, and traced off from the plan *C*, as the figures and letters direct, the ſoffit will then be completed.

If you would make a cylinder to be only the thickneſs of the wall, *D* ſhews the end of it, which is to be traced from the ſemicircle *B*.

How to draw a ſoffit when the top is a ſemicircle, cutting right into a circular wall.

FIG. *E.* This and the other below are performed the ſame as that above, with this difference, that you are to prick from the circular plan, inſtead of the ſtraight plan.

FIG. 1. ſhews the method when a circular headed window cuts oblique into a circular wall.

Note. In all kind of ſoffits, when the two jambs are parallel, the ſtraight line, which the ſoffit is pricked from, muſt be drawn at right angles to the jambs, as is ſhewn in this plate; for want of this conſideration they are ſhewn in books upon wrong principles.

But in the following ſoffits, where the jambs are not parallel, they muſt be continued till they meet in a point, and the line which the ſoffit is to be pricked from muſt be made iſocalas triangle with the jambs.

PLATE XII.

To draw a ſoffit in a ſtraight wall, fluing equally all round with a circular head.

In *fig. A*, continue the ſides of the plan *A*, that is *a c* and *b d*, to meet at *e*; then about the centre *e*, and from the points *a* and *c*, deſcribe the ſoffit *C*, and ſtretch the ſemicircle *B* along the outline of the ſoffit *C*, it will be completed.

To draw a ſoffit in a circular wall, fluing equally all round with a circular head.

FIG. *B.* The ſtretch out of this ſoffit is managed the ſame as in the laſt; draw the ordinates of the ſemicircle *B*, from thence continue them to *f*, the centre of the flue, and at the points *a b c d e*, where they interſect the plan, draw the parallel lines *a e*, *b f*, *c g*, &c. and from the points *e f g h* and *i*, circle lines to *a b c d* and *e* round the centre *f*, which will give the half of one edge of the ſoffit, the other half being pricked from it; the other edge is found in the ſame manner.

Note. This cannot be pricked from the plan as the others are, as the lines round the flue are not level with the plan, and will be longer than thoſe on the plan.

DEMONSTRATION OF FIG. *A.*

Conceive the ſemicircle *B* to be turned at right angles to the plan *A*, then every point in the circumference of the ſemicircle *B* will be at an equal diſtance from the point *e*, but the ſoffit *C* is deſcribed with the ſame radius; therefore the edge of the ſoffit *C*, that is the arch line *a f*, will exactly coincide with the arch of the ſemicircle *B*, which was to be proved.

DEMONSTRATION OF FIG. *B.*

It is eaſy to conceive from the laſt demonſtration, that if the ſemicircle *B* is turned up, and the ſoffit at *C* bent round it, the points 1 2 3 4 5 at *C* will coincide with the equal diviſions in the ſemicircle *B*, and the points *a b c d*, &c. at *C*, will fall perpendicularly over the points *a b c d*, &c. in the plan *A*; for the arches *a e*, *b f*, *c g*, *d h*, and *e i* at *C* will fall over the parallel ſtraight lines *e a*, *f b*, *g c*, *h d*, *i e*, in the plan *A*, which was to be demonſtrated.

The learner is adviſed to cut theſe and the following ſoffits out of paſteboard, and their demonſtrations will be more clearly ſeen.

Plate 12

A soffit cutting right into a straight wall Fluing equally all round

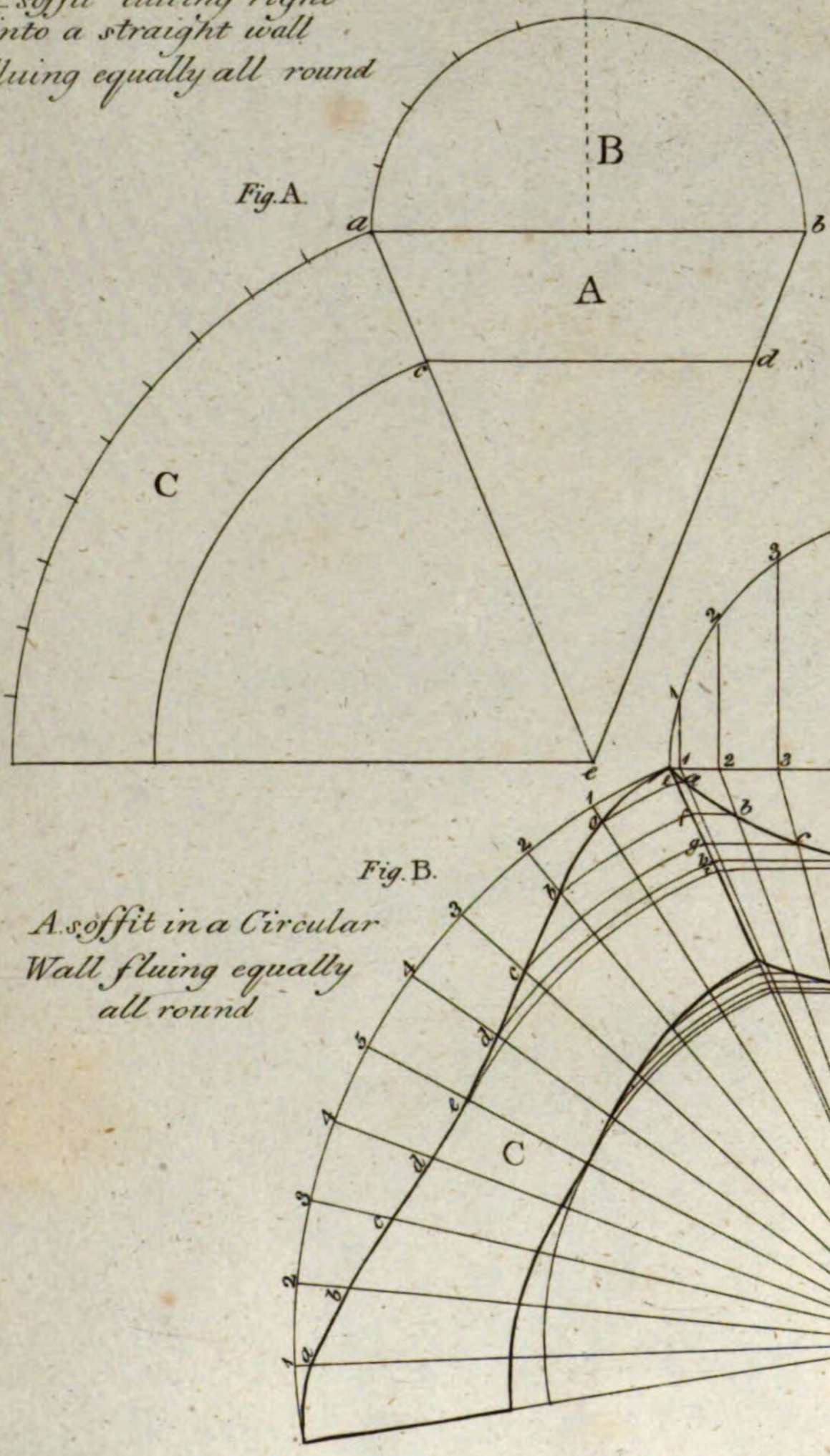

Fig. A.

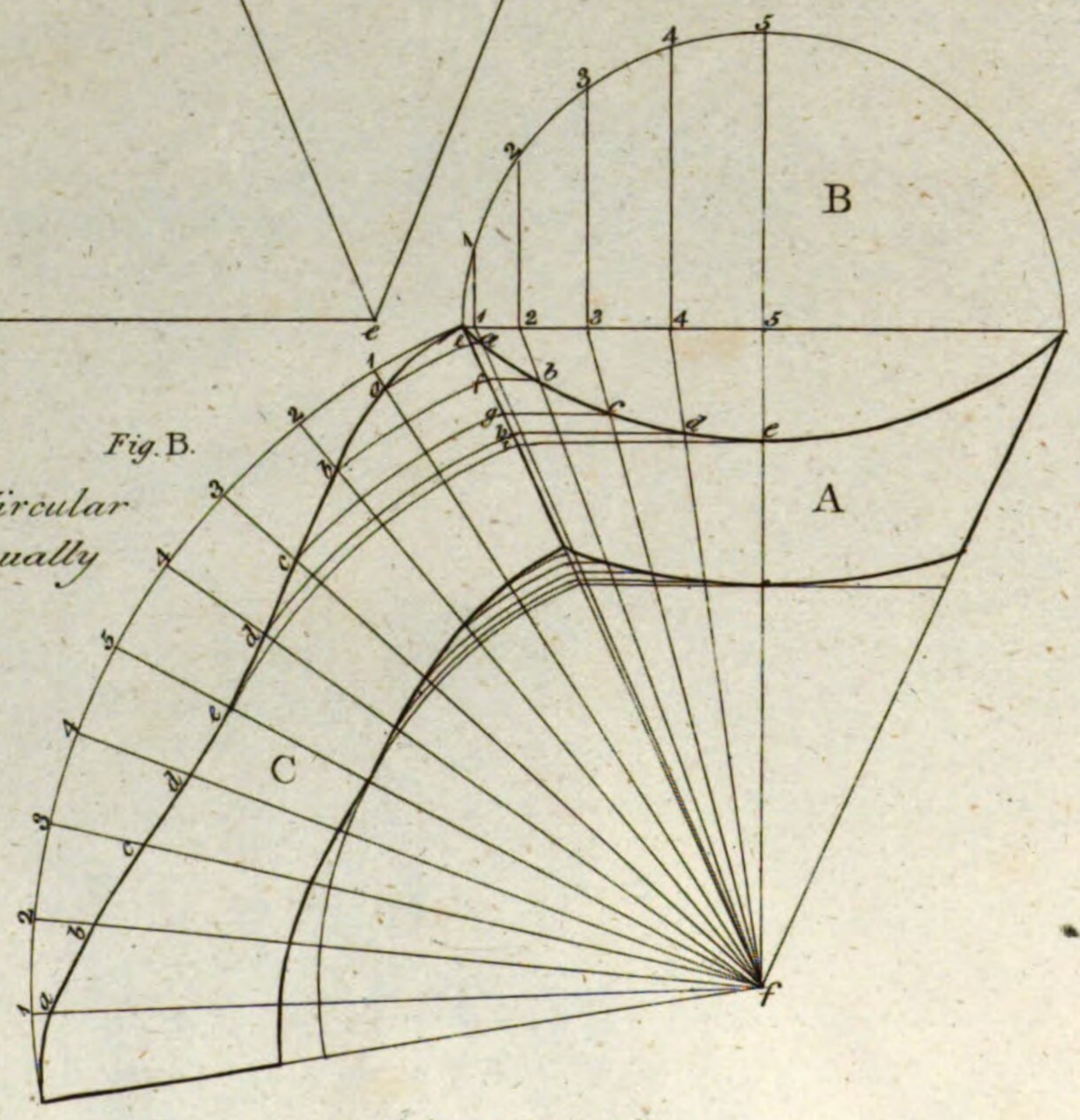

Fig. B.

A soffit in a Circular Wall fluing equally all round

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A Soffit fluing at the Jambs.
And level at Crown in a
Straight Wall.

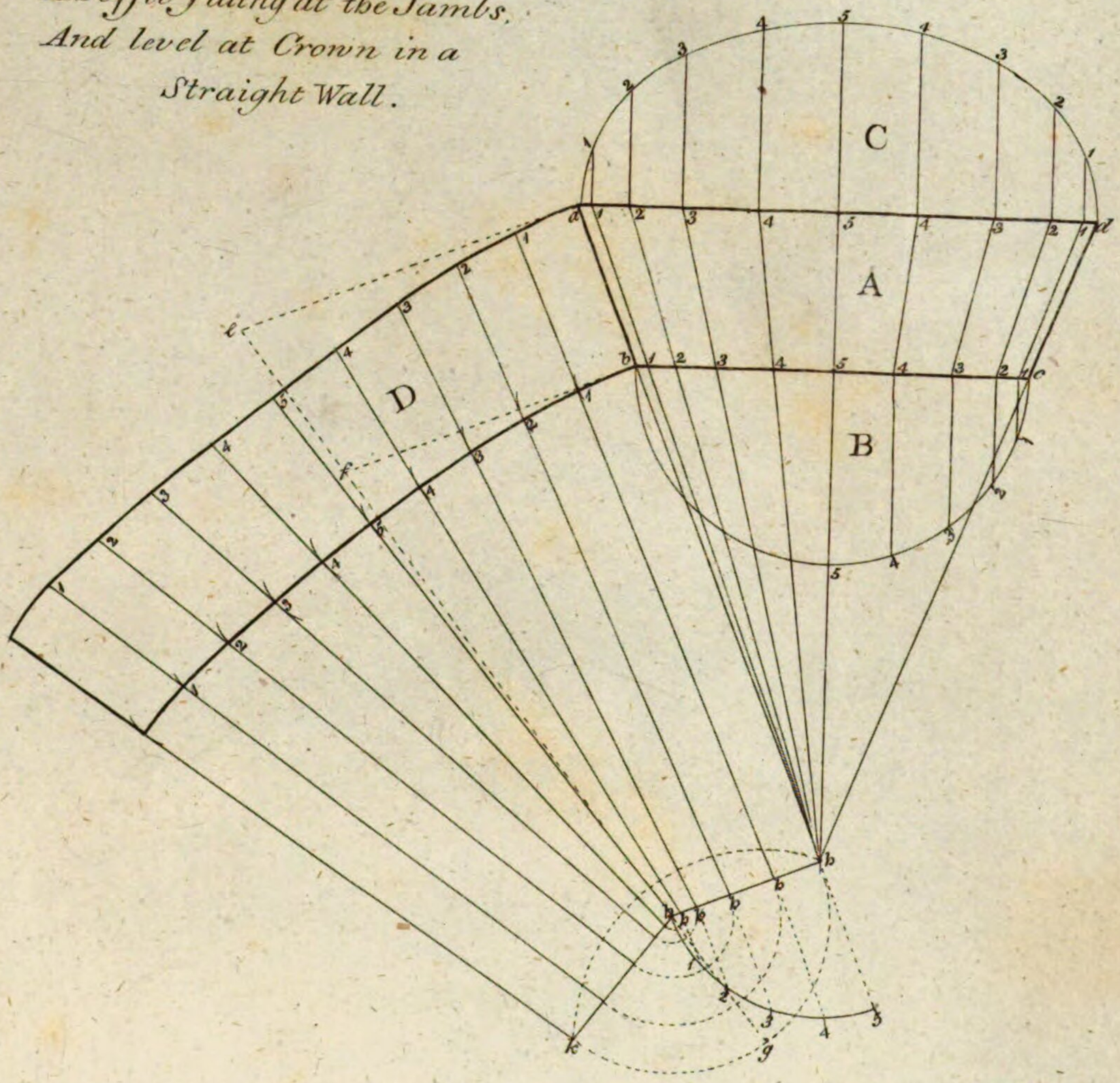

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Plate 14

A Soffit fluing at the Jambs and level at the Crown in a circular wall

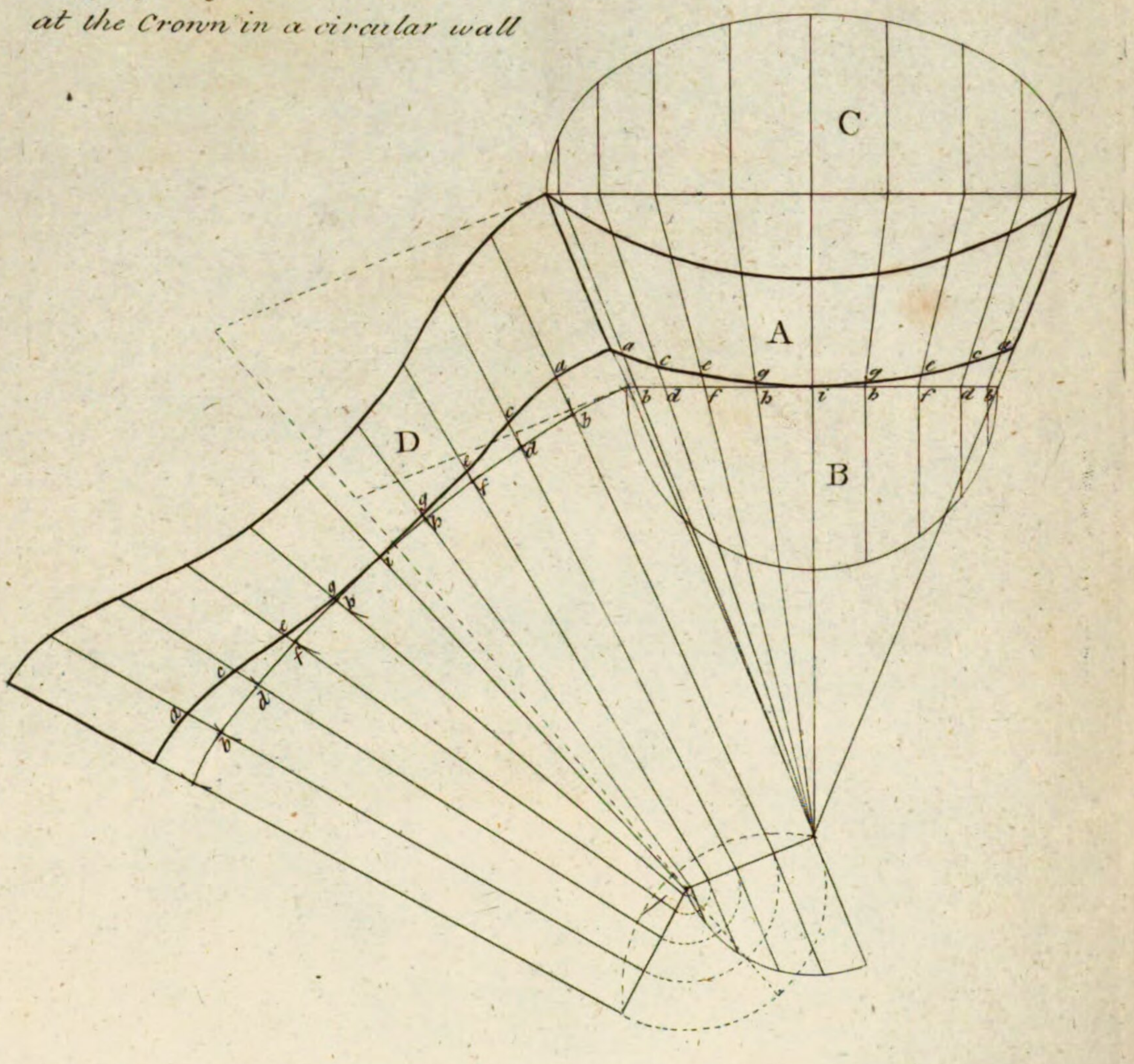

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PLATE XIII.

How to draw a ſoffit in a ſtraight wall, fluing from the jambs, and level at the crown.

A is the plan of the wall, *B* is a ſemicircle on the outſide, and *C* is an ellipſis in the inſide, traced from *B*, or got by a trammel; draw the lines *a e*, *b f*, and *h h*, all perpendicular to *a b* the ſide of the flue of *A*; then take half the compaſs of *B*, and lay it on *b f* in *D*; likewiſe take half the compaſs of *C*, and lay it from *a* to *c* in *D*, and through the points *e* and *f* draw a line to cut the line *h h h*, &c. in *h*, and continue it to *g*; put your compaſs in the centre of the flue at *h*, and with the other extreme point deſcribe the quadrant 1 2 3 4 5, which is divided into five equal parts, and draw ordinates 5 *h*, 4 *h*, 3 *h*, &c. then take one of the diviſions of the ſemicircle *B*, and ſet the foot in *b*, and make the ſmall arch at 1, and take *h* 1 from the centre of the flue in *A*; then put the foot of your compaſs in *h*, in the ſoffit, and with the other foot croſs the ſmall arch at 1; and with the aforeſaid diviſion of *B*, ſet the foot of your compaſs in 1 in the ſoffit *D*, and deſcribe the ſmall arch at 2; and take *h* 2 from the centre of the flue, and ſet that to its correſpondent *h* 2 in *D*, and by this means you will get one half of your ſoffit; put the foot of your compaſs in *h*, and with the other extreme *h* draw a circle *h g k*, and put the foot of your compaſs in *g*, and with the diſtance *g h*, that is from *g* to *h* the centre of the flue, deſcribe an arch from *h* round to *k*, and draw the line *h k* where theſe two arches interſect; then ſet the diviſions of *h h h*, &c. on *h k*, and deſcribe the other half in the ſame manner, and ſo the out-line of the ſoffit will be completed.

The inſide line is got by pricking it from the plan according to the figures.

PLATE XIV.

To draw a ſoffit in a circular wall, fluing from the jambs and level at the crown.

Proceed as in the laſt plate and get the line *b d f h i*, then prick the ſoffit *D* from the plan *A*, according to the letters.

In the ſame manner may any other ſoffit, fluing from the jambs and level at the crown, be drawn, let the form of the wall be what it will, by getting the line *b d f h i* firſt; then the ſoffit may be pricked from the plan whatever may be its form.

PLATE XV.

To draw a cylindrical ſoffit, cutting right in a wall which does not ſtand perpendicular to the ground, to a level baſe. FIG. *A.*

Let *a e* at *D* be the level of the ground, *a l* the inclination of the wall, equal to the radius of the cylinder, let fall the perpendicular from *l* to *c*, in the bottom line *a e* make the ſemi-circle in *fig. A*; to the width of the cylinder, or the double of *a l* at *D*, take the diſtance *a c* at *D*, and make *a b* equal to it in *fig. A*, and deſcribe a ſemi-ellipſis to the length of the ſemicircles *d d*, and to *a b* its width; lay the equal diviſions round the ſemicircle in *fig. A*, along the line *d d* double at *C*, then take the parts *e d*, *d c*, *c b*, *b a*, from the plan *B*, and lay them at *D* reſpectively from *e* towards *d c b*, and from *l* draw *l e* to make a right angle with *l a*, and at the points *a b c d* erect perpendiculars to *a e* to cut *l e* at *f g h* and *i*, take the diſtances *e i*, *i h*, *h g*, and *g f*, and lay them on the ſoffit at *C* reſpectively, from 1 *d*, 2 *c*, 3 *b*, 4 *a*, each way, then will the ſtraight line *d d* in the ſoffit, when bent round, be perpendicular over the elliptic line in the plan *B*, and the curve line *d d c b a d*, &c. will fall over the points *d c b a* in the plan: in the ſame manner the edge of the ſoffit may be brought to anſwer any curve line propoſed.

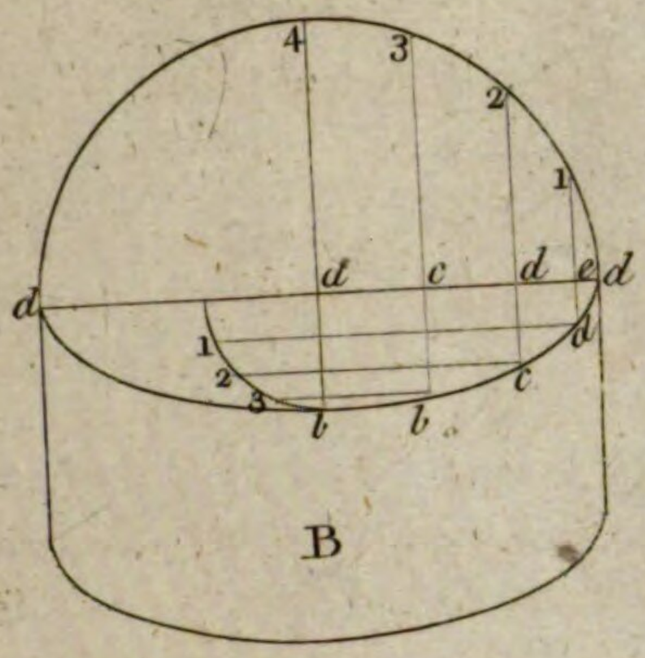
To draw the arches of groins by a new method, whether right or rampant, ſo that their arches ſhall interſect or mitre truly together, from a given arch of any form.

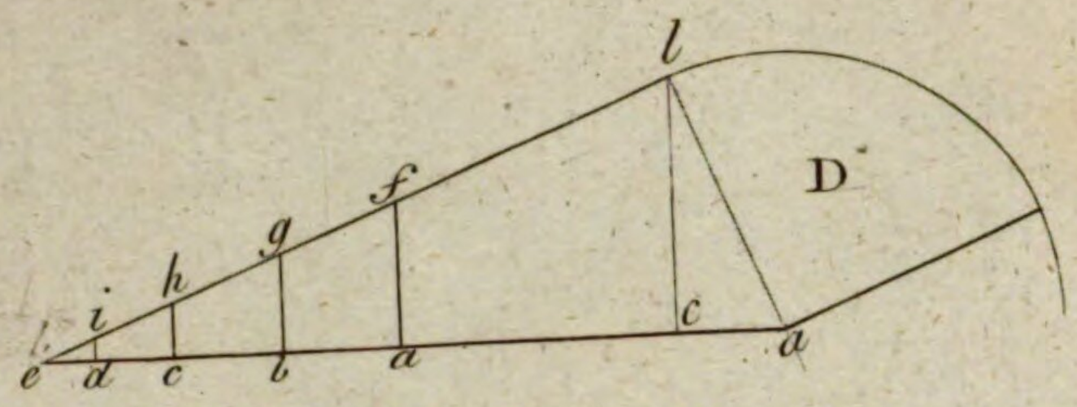
Let *fig. E* be the given arch of a gothic form, draw the chord *a c* for one half the arch, divide it into any number of parts, as 4, and through the equal diviſions draw lines from the centre *e* to terminate in the circumference at *h g l*, draw lines from *c* through *h g l* to cut the perpendicular *a d* at *b*, *c*, *d*; and if No. 2 is required to be wider, but the ſame height as *fig. E*, draw the two chords *a c* and *c b* for each ſide of the arch, divide each into four equal parts, as before, and ſet the diviſions *a*, *b*, *c*, *d*, perpendicular on each end of *a b* at No. 2, and from theſe diviſions draw lines to the crown at *c*, then trace the curve through the points *h g l*, &c. ſo the arch at No. 2. will truly mitre into *fig. E*; in the ſame manner the rampant curve at No. 3, will be brought to correſpond with *fig. E* and No. 2 *.

* Nothing can be more ready than this in practice, becauſe a chalk line will ſoon ſtrike all the radial lines, having only to move it but once from the point *e* up to *c* at the crown; *fig, F* ſhews the common method by dividing the baſis of each into a like number of parts, and transferring the height, as the figures explain, at No. 1, and No. 2; nothing is more tedious in practice than raiſing a number of large perpendiculars, and going continually from one curve to get the height of another.

Plate 15

Fig A





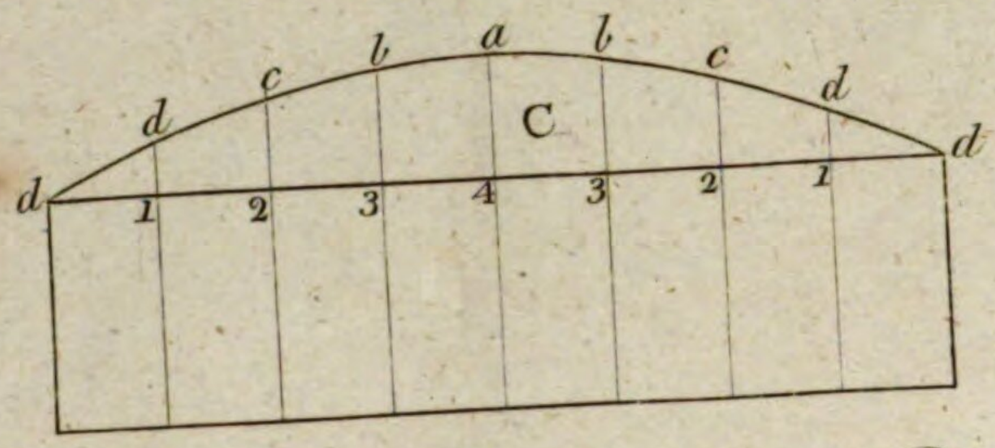
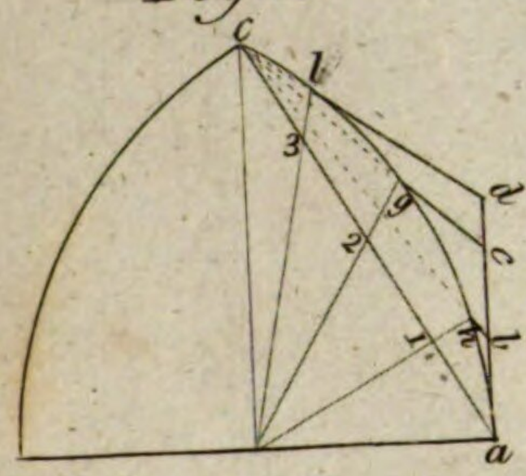
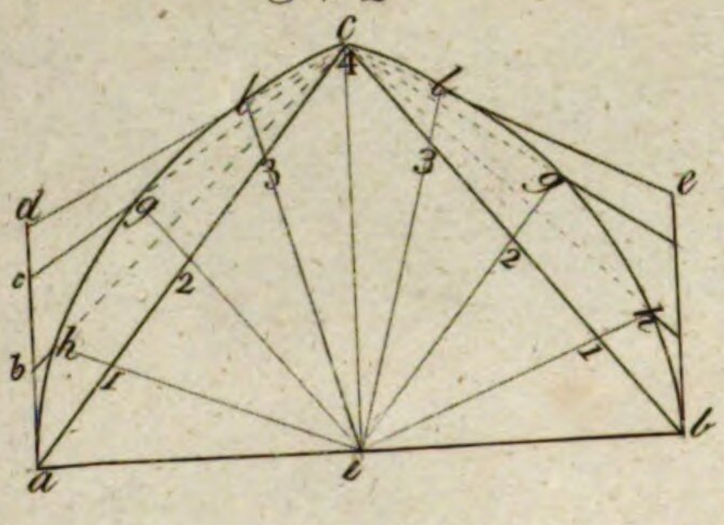


Fig E



N.° 2



N.° 3

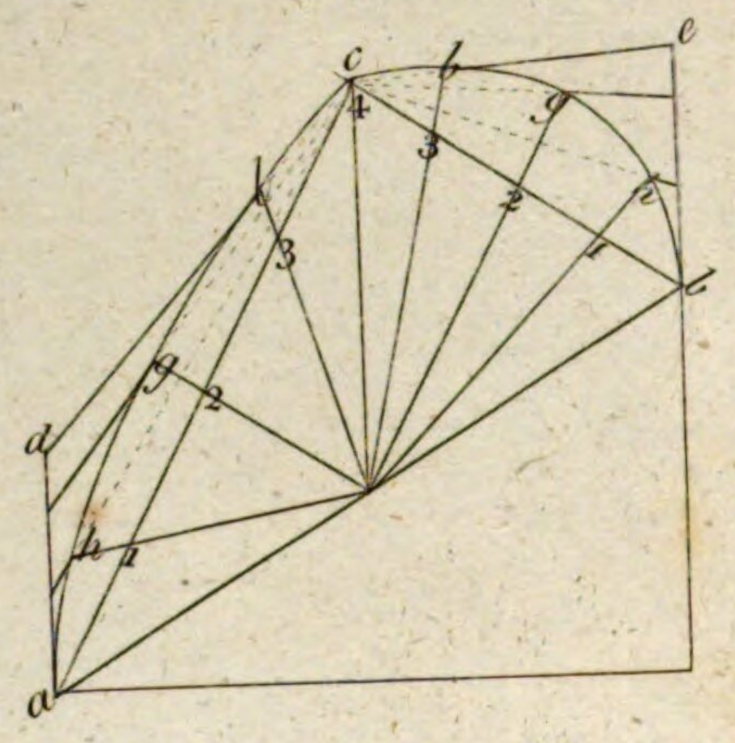


Fig F

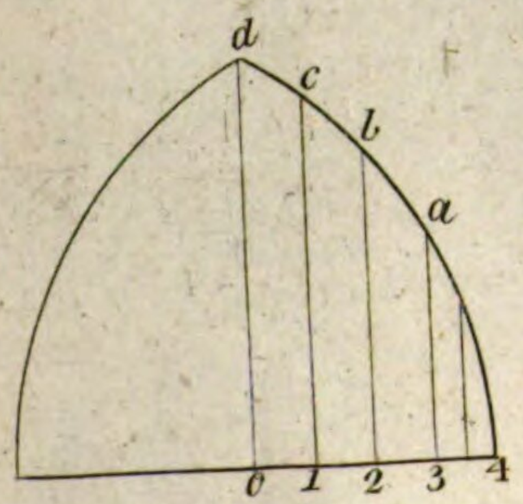


Fig F N.° 1

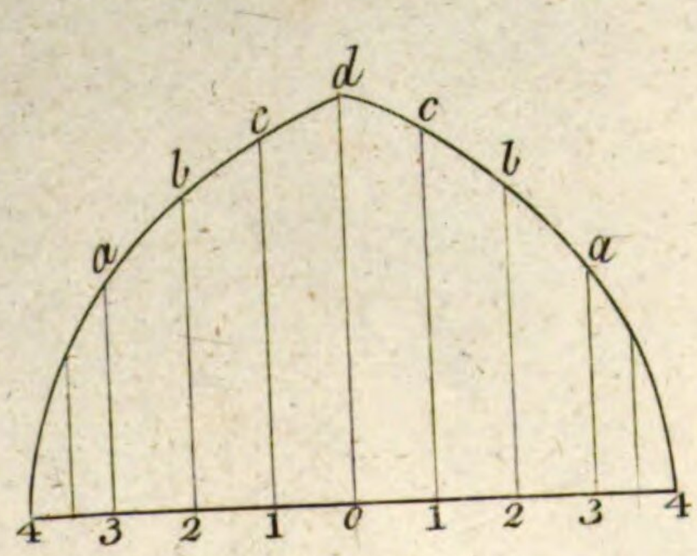


Fig F N.° 2

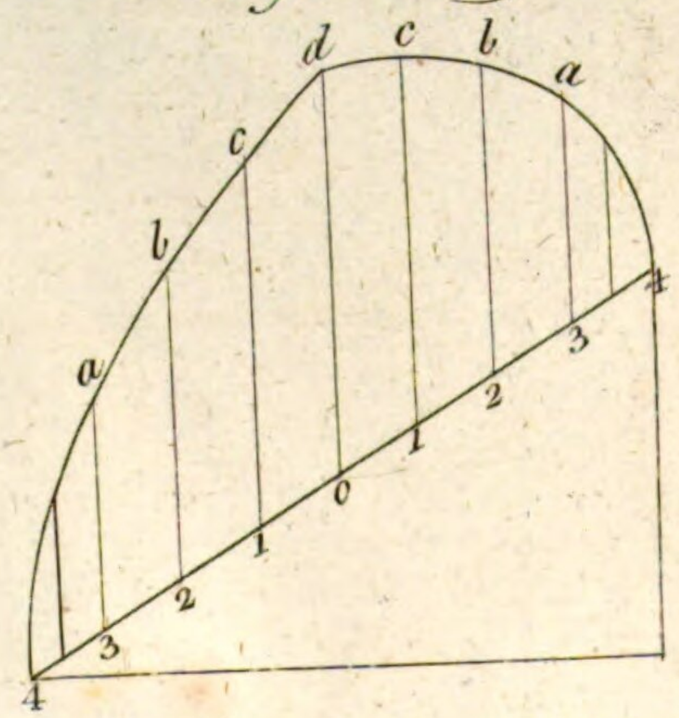


Plate 16

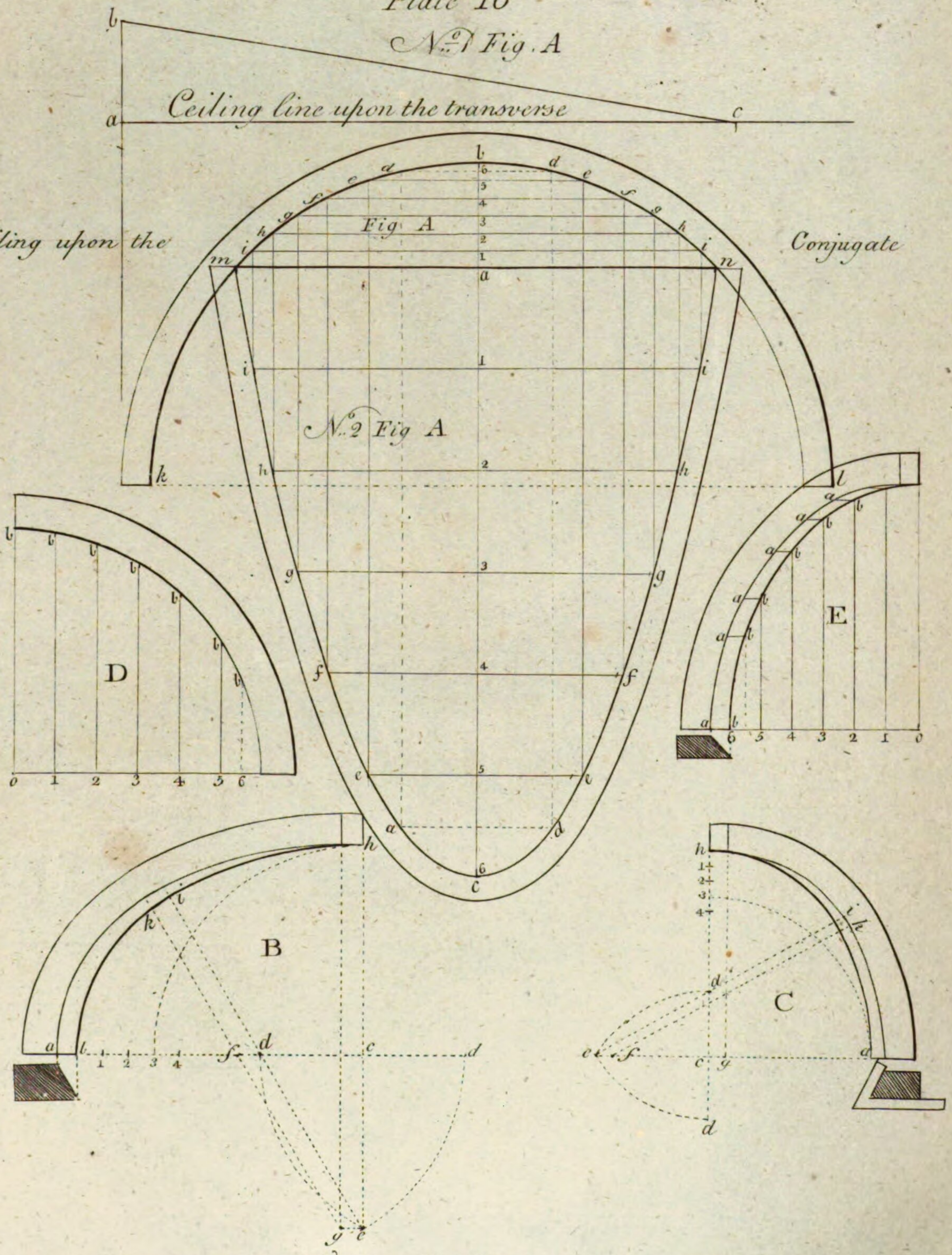


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PLATE XVI.

As it happens ſometimes in church work, that windows go higher than the ceiling line, therefore the ceiling wants to be hollowed out, ſo that the light moy be thrown down into the body of the church; I ſhall, in this place, ſhew the method of making a curb for that purpoſe.

To find the form of the curb.

Let *k b l* be the head of the window, *figure A*, and let it come as high as *a b*, above he ceiling *; and let *a b* at No. 1 be the ſame height, and *b c* the direction of the light, nd *a c* will be the length of the curb. Make *a c* at No. 2, equal to *a c* at No. 1, and divide it into ſix equal parts; alſo divide *a b*, in *figure A*, into ſix equal parts, and let the ordinates be drawn as is explained in the figure, a curve being traced round the points of interſection, will give the form of the curb.

Figures *B* and *C* ſhew the method of drawing and backing any elliptic rib with a compaſs, which is exceedingly handy in drawing, and will be near enough for the repreſentation of an elliptic rib on paper, as no other method will be ſo clean when done; but for practice, nothing is more handy than a trammel, or interſecting lines.

* The ceiling is here ſuppoſed to be level, which is ſeldom the caſe in a church; but the method will be nothing different if the ceiling line *a e* was to incline to the horizon in any angle whatever.

To draw and back ribs by this method.

In *B*, let *c h* be the height, and *c b* the width; divide the difference into three equal parts, and ſet four ſuch parts on each ſide of *c*, to *d* and *d*, and make an interſection with the diſtance *d d* at *e*, and draw a line through *e* and *d* out to *i*, then *d* and *e* are the centres for the ribs. And ſuppoſe the rib is to be backed as much as *a b* upon the bottom, ſet *a b* from *d* to *f*, and from *e* to *g*, parallel to the baſe; and draw a line through *g f*, out to *k*; then *g* and *f* are the centres for deſcribing the backing.

The rib *E* is traced from *D*, and *a b* is ſet all round on the parallel lines, ſhews the backing is alſo uſed for drawing on paper.

The method of drawing the rib *C* is only the reverſe of the other at *B*, and therefore wants no other deſcription.

Note. The word *backing* ſignifies the beveling of any rib, ſo as to range in a ſtraight or regular curve line with any other number of ribs already fixed; nothing is more difficult to underſtand in the practice, where groins or other arches meeting together do not form a ſtraight line upon the plan, then the ſhifting of a mould cannot be applied to a curve ſurface as it is to a ſtraight one; in this caſe we muſt have recourſe to another method.

PLATE XVII.

DEFINITION.

Groins are the interſection of arches or vaults cutting acroſs one another, meeting on their diagonal ſections.

BRICK GROINS. DESCRIPTION.

A, *a*, *a*, *a*, &c. is the plan of the piers which the vault is to ſtand upon, *a b* is the end opening, which is a given ſemicircle; in this *b c* is the opening of the ſide arch, which is to come to the ſame height as the end arch *a b*: fix your centres over the body range, *fig. A*, as ſhewn in the ſection at *C*, then board them over. In *fig. A* is the manner of fixing the jack ribs upon the boards, which likewiſe ſhews at *C*.

To find the mould for the jack ribs.

Take the openings of your arches in *fig. A*, that is *a b* and *b c*, and lay them down in *fig. D*, at *a b* and *b c*, to make a right angle. Divide one half of the given ſemicircle *E* into five parts, and ſquare them acroſs 1 1 1, &c. to cut *d b* and *d c*, the diagonals, in 2 2 2, &c. and through the points 2 2 2, &c. draw lines parallel to 1 1 1, &c. the baſe of *E* both ways towards *F* and *G*; ſtick in nails at 1 2 3 4 5 in *E*, and bend a thin ſlip of wood round them, which mark with a pencil at every nail; this ſlip of wood being ſtretched out from *d*, 1 2 3 4 5, and ſquared over to *G*, will interſect the other lines in ſmall ſquares: a curve being traced through the diagonals of each ſquare, will give a mould for to ſet the jack ribs.

How to fix the jack ribs.

Bend your mould *G* from *d*, to the crown at *e*, in *fig. A*; that will give the edges of your boards; then fix a temporary piece of wood, level upon the crown, in the direction of *f f*, and let it come the thickneſs of your boards lower than the crown, then it will give the height of your jack ribs, which is a very ſure method of placing them.

To find a mould to cut the ends of the boards.

The rib *F* is traced to the height of *E*, or got by a trammel, which will be fully exemplified in the following plates. Take the parts round *F*, and lay them out to 1 2 3 4 5; then *H* will be got in the ſame manner as *G*, which will be a mould to cut the ends of your boards that goes upon the jack ribs againſt the body range.

FIG. 1. *Is an eaſy method of getting the moulds when both arches are the ſame opening.*

Take half the opening of the arches, whatever they are, and draw a quarter circle, and divide it into ſix; bend a ſlip round it to take its parts, then ſtretch it out upon the baſe from 1 to 6, and ſquare over your points 1, 2, 3, &c. Through the points in the arch draw the lines on both ſides the other way, and being traced as before, gives both moulds, being the ſame in this.

Note. The curve *F* may be drawn in practice with a trammel, independent of the other, and the two moulds *F* and *G* may be drawn ſeparate, without any connection of lines, as ſhall be ſhewn hereafter.

Plate 17

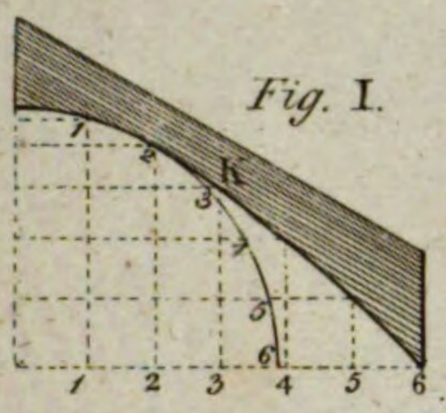
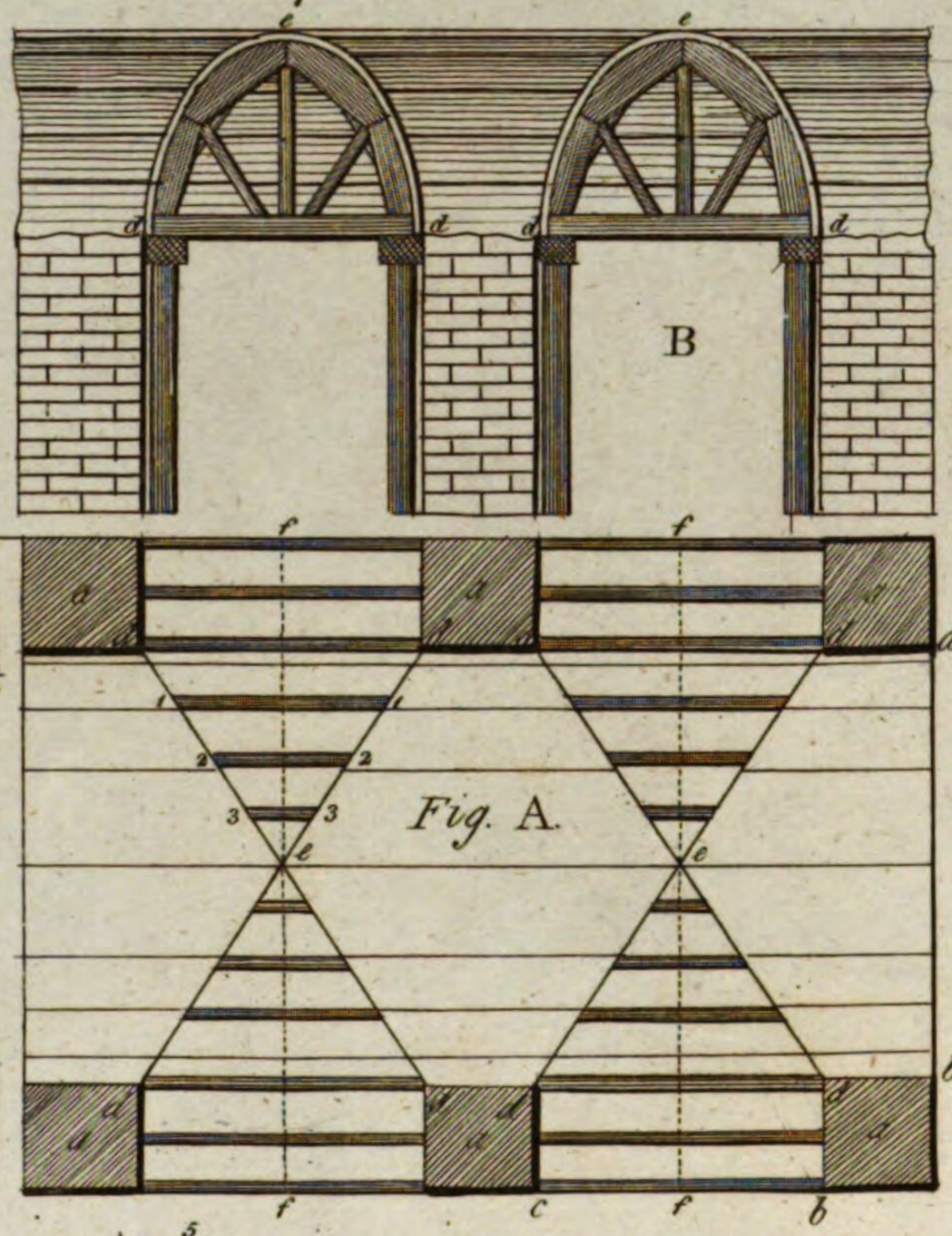


Fig. I.



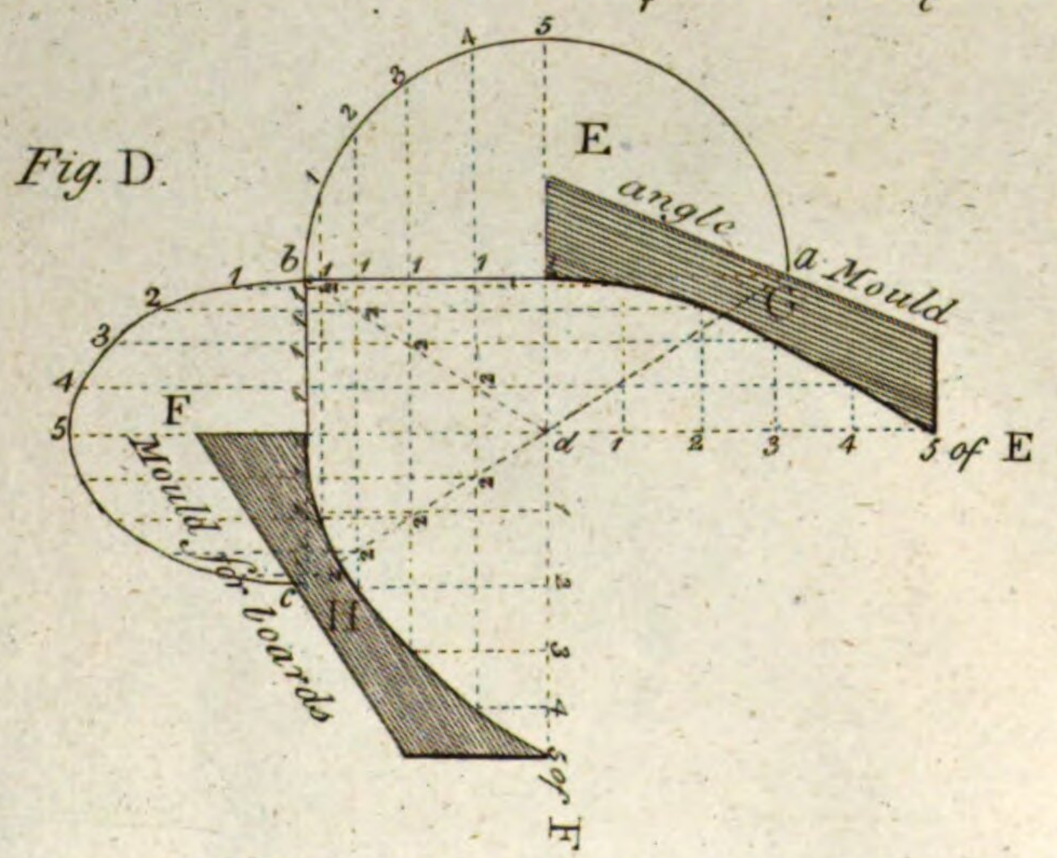


Fig. D.

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Plate 18

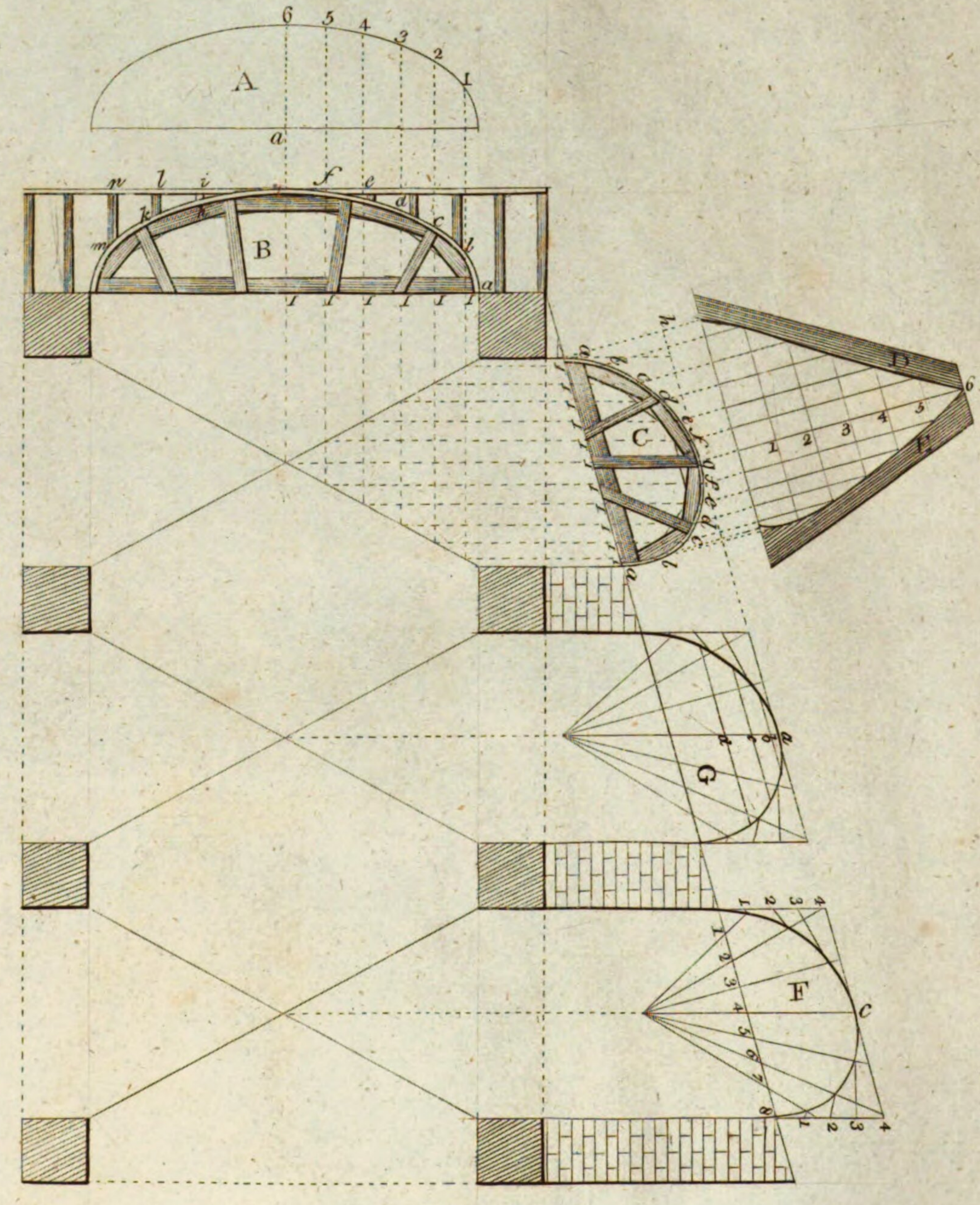

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PLATE XVIII.

DEFINITION.

Groins are ſaid to be aſcending or deſcending when they are not built upon level ground.

CENTERING FOR ASCENDING OR DESCENDING GROINS.

The plan, and aſcent or deſcent, of any groin being given, and one of the body ribs, as B, *alſo the place of the angles upon the plan, to find the form of the ſide ribs, ſo that the interſection of both arches will be perpendicular over the plan.*

Divide half the circumference of the given rib *B*, into any number of equal parts, and draw them to interſect the angles; and from thence let them be returned up to the rib *C*, upon the ſide; then *C* being pricked from the given rib at *B*, as the letters direct, will give the form of theſide centre. The ſame is ſhewn at *F*, by the method of interſecting lines.

To find the two moulds D and E for placing the jack ribs, to bend over the angles in the body range, when boarded in, ſo that they may be perpendicular over the angles upon the plan.

At *C*, draw lines from the points *a b c d e f g*, &c. where the ordinates of *C* interſect the top of the arch, and perpendicular to the rake, and draw the ſemi-ellipſis *A*, to the width of the body range; and to *a h*, the height of the ſide centres, perpendicular to the rake; and continue the ordinates of *B*, up to *A*, to interſect at 1 2 3 4 5 6. Bend a ſlip round theſe points, and mark them oppoſite to every point, and ſtretch it out along *k* 1 2 3 4 5 6, between *D* and *E*, and draw lines through theſe points, at right angles to *k* 6, to interſect with the perpendiculars. Begin at 6, and trace a curve both ways, will give the edges of the two moulds for placing the jack ribs.

To cut the jack ribs to the rake of the groins.

Set the number of the jack ribs upon the arch *B*, at their proper diſtances, and take their ſeveral heights, that is, *h i*, *k l*, and *m n*, and ſet them upon the arch *G*, from *a* to *b*, and from *a* to *c*, and from *a* to *d* draw lines through theſe points parallel to the rake, which will ſhew how the jack ribs are to be cut, ſo that they ſhall range properly with the other raking centres.

Note. All the body ribs muſt be backed according to the rake of the groin; to do this exactly the under edges of all the ribs muſt be beveled according to the rake; then make a mould as *B*, or one of the body ribs themſelves will anſwer inſtead of a mould, which being applied to each ſide of any other rib, keeping the bottom fair with the under edge upon each ſide, and drawing the curves by the other, it will give the backing in this caſe.

PLATE XIX.

Given the two ſide arches of any groin, and the aſcent; to find the interſection of the angles upon the plan.

Divide half of the body rib *B*, into equal parts, and draw parallel lines to *b c d e* and *f*; and on the point *a*, as a centre, draw the concentric dotted circles round to *g h i k l*; then draw parallel lines to the rake, to cut the centre *C*, at 1 2 3 4 5, and *a b c d e* on the other ſide; and from theſe points let lines be drawn perpendicular through the plan. And on the centre of the rib *C*, at *g*, ſquare a line up to 5, the top of the arch *C*; and from 5 draw a line perpendicular through the plan. Alſo through the points 1 2 3 4 5, at *B*, draw perpendicular lines to the plan the other way; begin at *h*, and trace through the angles both ways, will give the place of the angles upon the plan.

The moulds for bending over the angles are found in the ſame manner as in the laſt plate, by taking the ſtretch out round *A*, and laying it between *D* and *E*.

The Reader may ſee ſuch groins executed under the Adelphi Buildings in the Strand, London, where the deſcent is very rapid in going down to the river.

The jack ribs of the groin are cut in the ſame manner as directed in the laſt plate, and in the practice there will be no occaſion for tracing the angles, as the two moulds *D* and *E* are done independent of them: the Reader will farther obſerve, that the arch *B* muſt not be uſed inſtead of the arch *A*, which would produce a very great error in the moulds *D* and *E*, as it muſt be evident to every one, that the ſection upon the ſquare of the cylinder, or body range, muſt be leſs in the height than the perpendicular or plumb ſection *B*, which in this caſe is oblique; if theſe things are properly underſtood, there will occur nothing in brick groins but what may be eaſily ſurmounted.

In all kinds of brick groins the centres or body ribs muſt be fixed firſt in the ſame manner as if there were no ſide-arches cutting acroſs them; then the centres muſt be boarded over; then to find the place of the angles upon the boards, that is, the proper interſection of the ſide-arches upon the plan, the moulds *D* and *E* muſt be both bent round the boards at one time, by keeping the points *l* and *e* of the moulds *D* and *E* upon the tops of the piers at *o* and *e*; then keep the top points together, and bend them round, keeping them ſtill together, then the point at 5, will fall perpendicular over *h* in the plan; round the inner edges of the moulds draw a curve upon the boards, which will be the proper interſection of the ſide-arch. The jack ribs are cut in the ſame manner as directed in the laſt.

Plate. 19

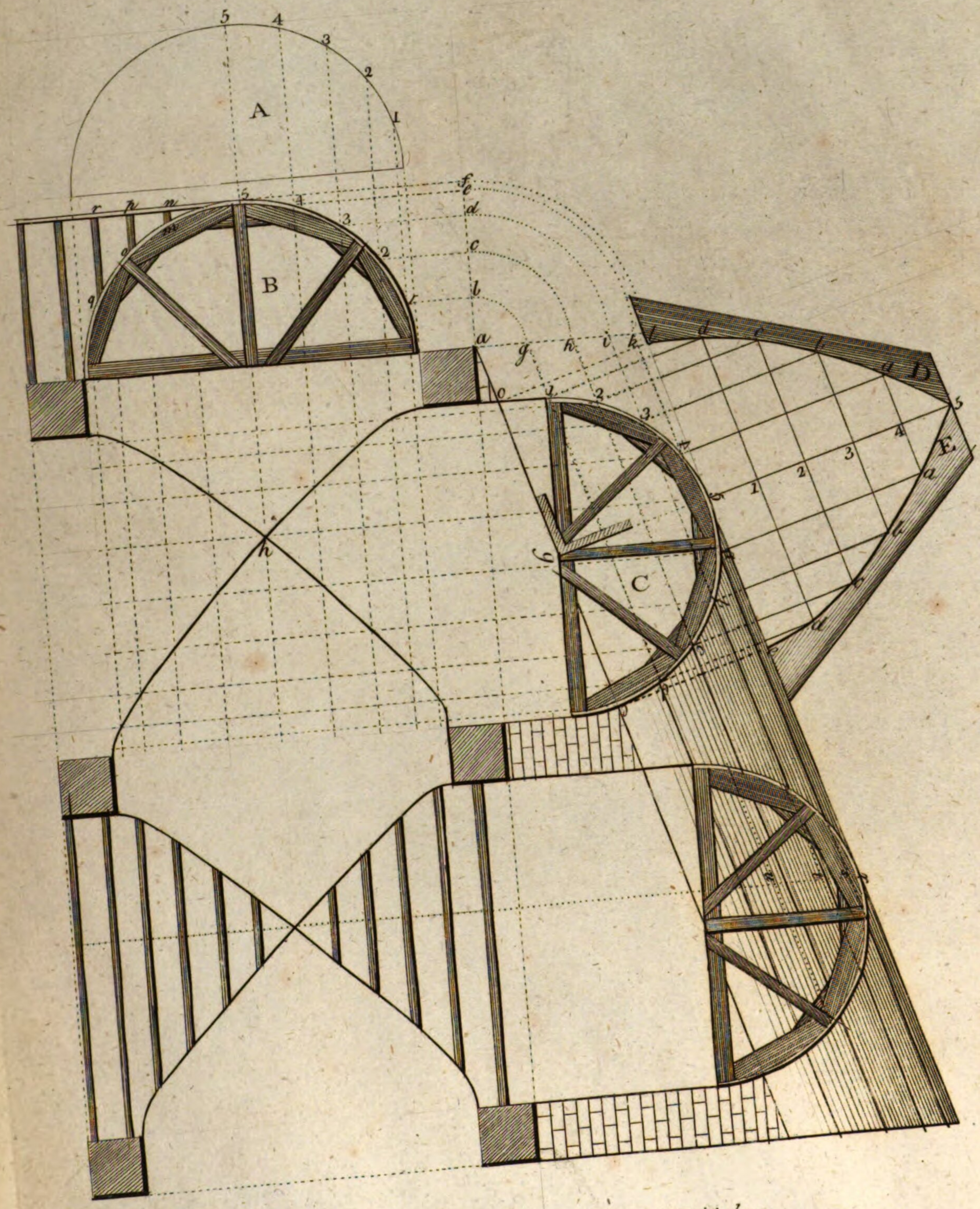

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Plate 20.

Fig. 1.

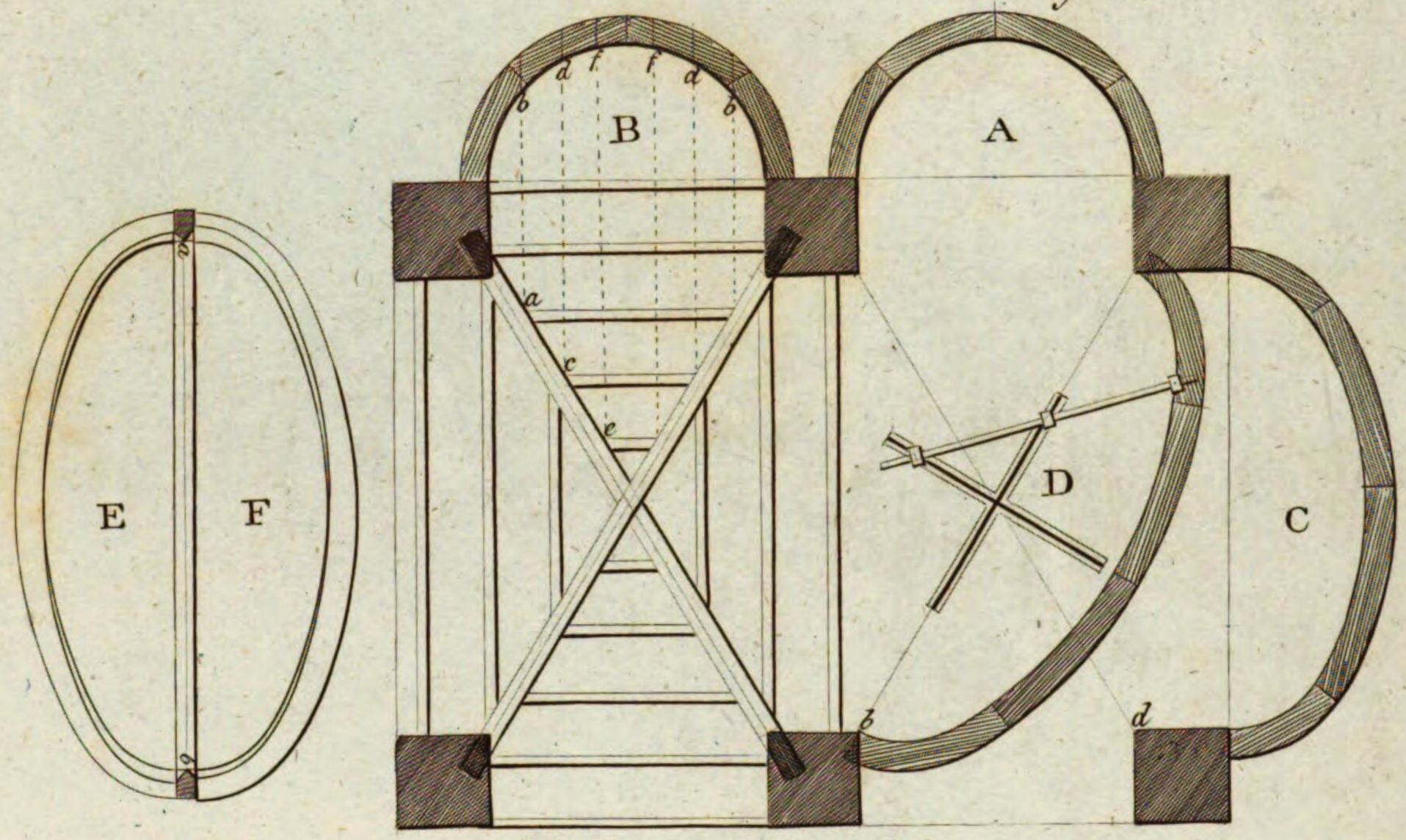


Fig. 2.

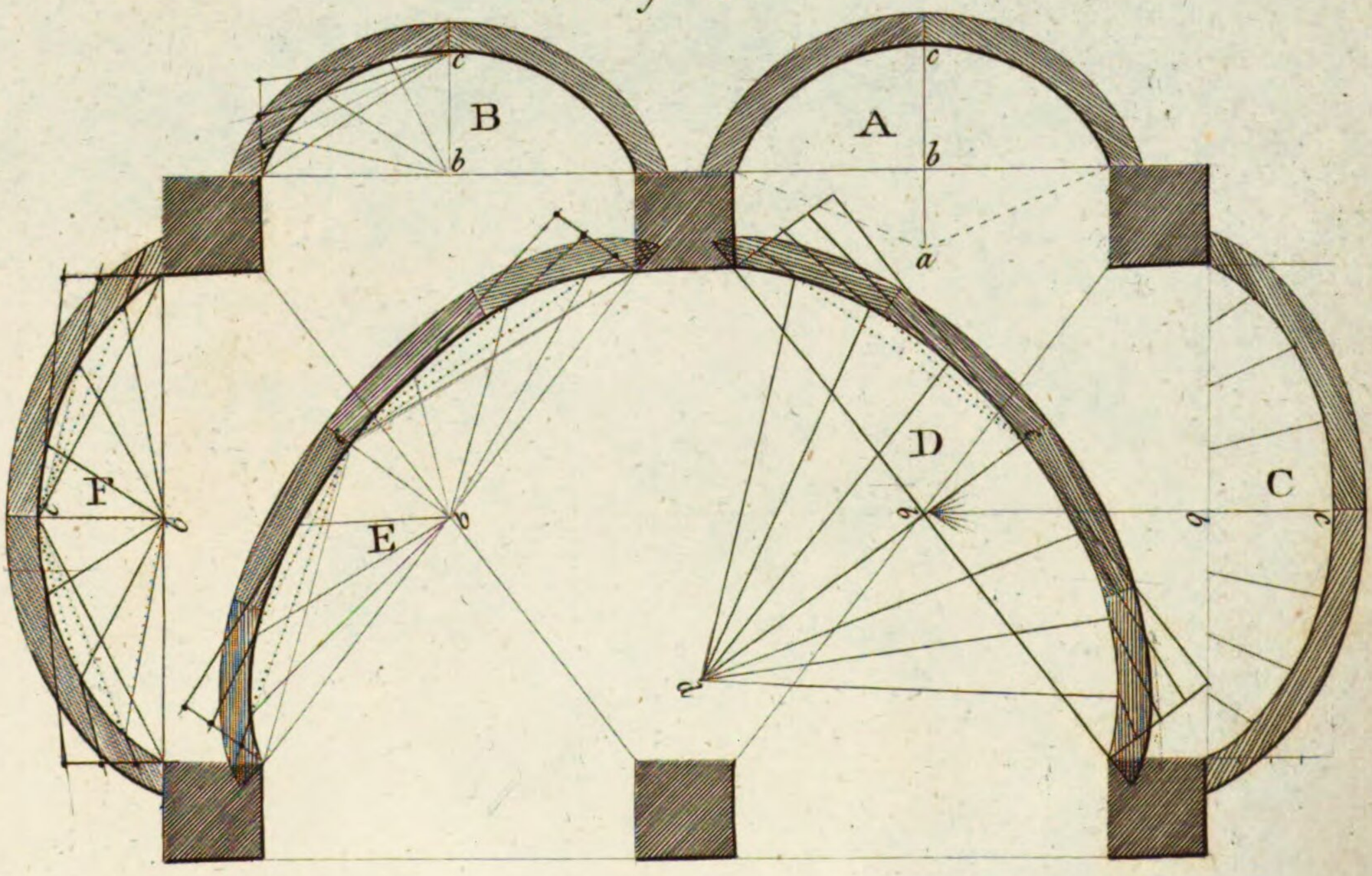


PLATE XX.

PLAISTER GROINS.

The angles or diagonals of any plaiſter groin, which are ſtraight upon the plan, and one of the ſide arches being given, to find the other ſide arch and angle rib.

FIG. 1. CASE 1. If the given rib is a ſemicircle ſemi-ellipſis they may be deſcribed as in *fig.* 2, plate 6, with a trammel, which is by far the readieſt method; but if a proper trammel is not to be got, a temporary one may eaſily be made, which will anſwer equally as well, by fixing two pieces of wood in the form of a ſquare, that is to make a right angle; each leg muſt be as long as the difference between the ſemi-tranſverſe and ſemi-conjugate axis, and inſtead of the ſliding nuts in the rod, two brad awls will anſwer the purpoſe, being put through any ſtraight ſlip of wood, and by moving this round either the exterior or interior angles of the ſquare, keeping the pins or brad awls cloſe to each leg, it will deſcribe one quarter of an ellipſis at one time.

To find the length of the jack ribs.

Lay down the plan of the ribs, as at *B*, and draw a rib upon each opening; then draw perpendicular lines from the plan of each opening, at the extremities *a c e*, to cut its correſponding rib at *b d f*; then the diſtance from *b* to *b* ſhews the length of the firſt jack rib, from *d* to *d* the length of the ſecond, and from *f* to *f* the third.

How to back or bevel the angle ribs, ſo that they ſhall range with each opening of the groin.

Firſt get the ribs out in two halves or thickneſſes, as at *E* and *F*, then draw the plan of your angle rib which is placed between *E* and *F*, will ſhew the true bevel upon the bottom of the rib; then ſhift your hip mould parallel upon the baſe of *E* and *F*, will ſhew how much wood there is to be bevelled off; then nail the two halves together, and it will be completed.

METHOD I.

FIG. 2. CASE 2. When the given rib is a ſegment of a circle, or any other curve whatever, the ribs will be deſcribed as in plate 15, *fig.* *E*, as are ſhewn at *B*, *E*, and *F*.

METHOD II.

When the given arch is a ſegment of a circle as at *A*, take its height *b c*, and place it from *b* to *c* at *C* and *D*; then take the whole diameter of the arch *A*, that is, twice the radius *a c*, and place it from the crown of the other arches perpendicular to their baſes from *c* to *b* at *C*, and from *c* to *d* at *D*; then the arch may be drawn as in plate 8, by interſecting lines: the backing of the ribs is done in the ſame manner as in the laſt groin.

Either of theſe two methods are much readier in practice than tracing the ribs through ordinates.

PLATE XXI.

Given one of the body ribs, and the angles ſtraight upon the plan, and the aſcent of a groin not ſtanding upon level ground, to find the form of the aſcending arches, and the angle ribs.

Let *b a c* at *B* be the angle of the aſcent, from the point *b* make *b c* perpendicular to *a b*, and deſcribe the rampant curve *B*, as in plate 15, at No. 3, in *fig. E*; then draw the diagonal *a b* at *E*, and make *b c* perpendicular to it, and equal to *b c* at *B*; then draw the hypotenuſe *a c*, and deſcribe the angle rib *E*, in the ſame manner as that of *B*.

To find the length of the jack ribs, ſo that they ſhall fit to the rake of the groin.

Draw lines up from the plan to the arch, as at *D*, in the ſame manner as explained in the laſt plate; then the arch from *a* to *a* is the firſt jack rib, from *b* to *b* the ſecond, and from *c* to *c* the third, &c.

How to back the angle ribs for ſuch ſort of groins, ſo that they ſhall range each way.

Get the ribs out in two halves, as in the laſt plate, then the bottom of the ribs muſt be bevelled agreeable to the aſcent of the groin, and the plan of it muſt be drawn upon the level, and from thence they may be drawn perpendicular from the plan to the rake of the rib; then take a mould to the form of the rib, or the rib itſelf, and ſlide this agreeable to the rake to the diſtance that is marked upon the bottom to be backed off, will ſhew how much the rib is to bevel all round.

Plate 21.

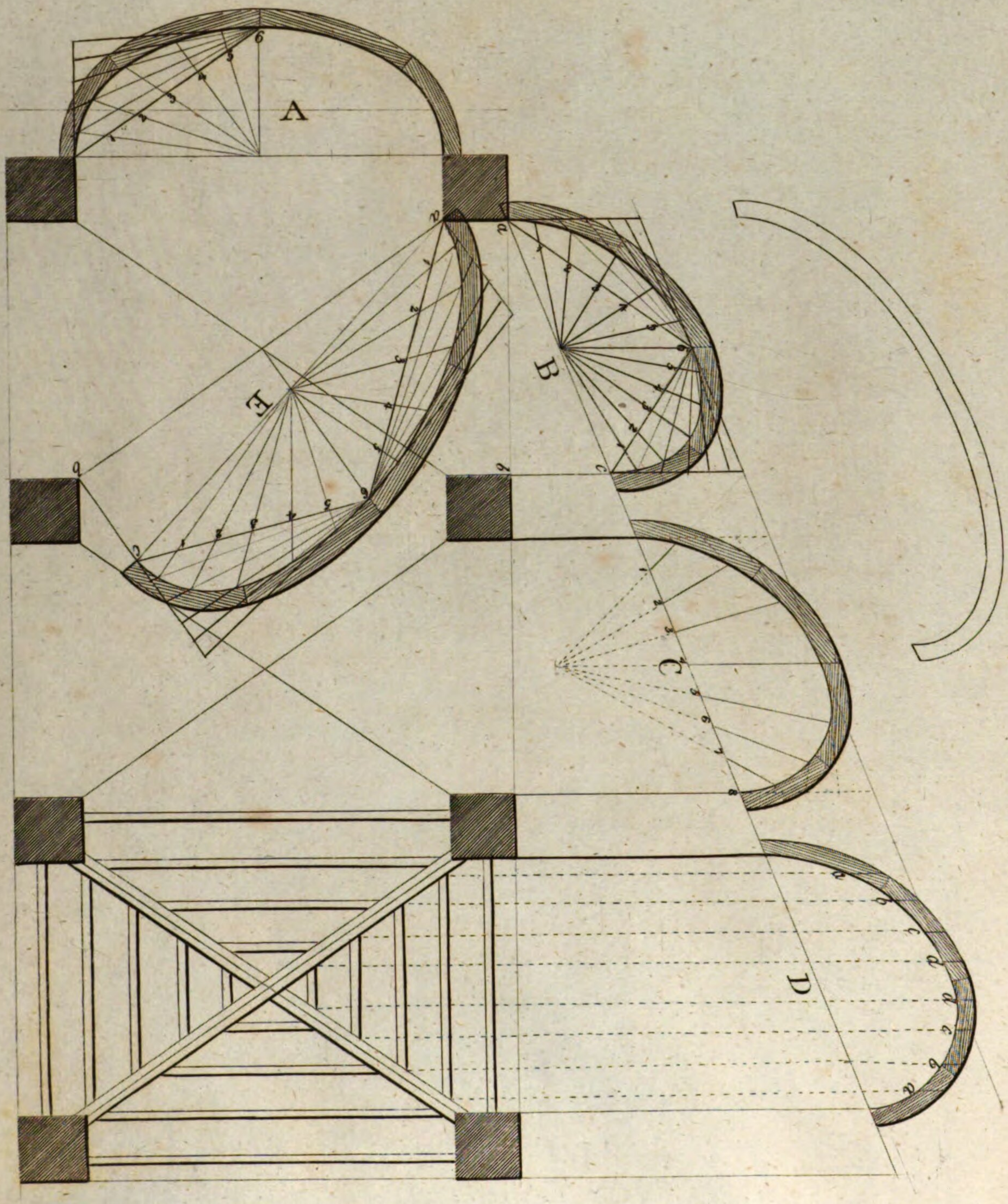


Plate 22.

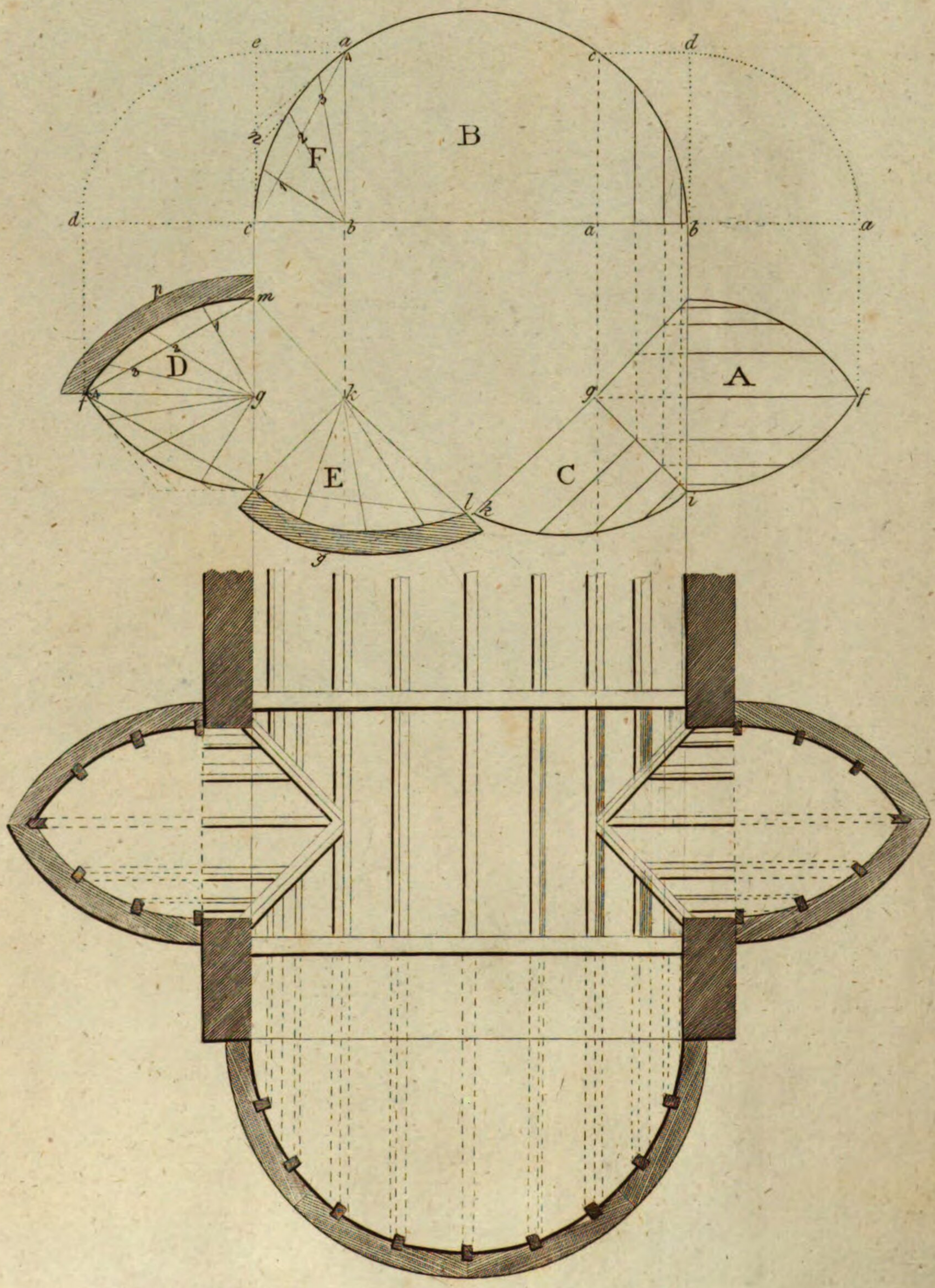


PLATE XXII.

OF GROINS CUTTING UNDER PITCH.

DEFINITION.

When the ſide arches of a groin are lower than the body arch, then they are called under pitch groins.

Given one of the body ribs B, *and the height* f g, *of a door or window, &c. at* D, *and its width* m l, *to find the ſide and angle ribs* D *and* E, *ſo that the interſection of the ſide arch* D, *with the body rib* B, *ſhall be ſtraight upon the plan.*

Draw *c e* perpendicular to *c b*, the baſe of *B*, and equal to the height of the window at *D*, that is, equal to *f g*; through *e* draw *e a* parallel to *c b*, cutting the arch *B* in *a*; let fall the perpendicular *a b* to *c b*, and continue it ſo as to cut the line *f g* produced to *k*, and draw *k m* and *k l*, which is the place of the angles upon the plan, or the baſe of the angle ribs: then the ribs *D* and *E* may be deſcribed from the given rib *F*, as directed in plate 15, *fig. E*, from a centre; or they may be deſcribed as at *fig. F* of the ſame plate, as you ſee on the other ſide at *A* and *C* by ordinates: but the firſt is by far the eaſieſt method for practice, for if you ſtick a pin or brad awl in *g*, at *D*, and lay a chalk line to it, you may ſtrike all the radial lines *g* 1, *g* 2, *g* 3, *g* 4, &c. in much leſs time than the parallel lines in *A* and *C* can be drawn, and with much greater accuracy; and the diviſions upon *c n* of the arch *F*, may be marked upon a rod, and readily transferred to the arches *D* and *E*, on *m p*, and *f g*: then move your brad awl out of *g*, and ſtick it in the crown at *f*, and ſtrike lines from the diviſions of *m p* to croſs the other lines, will give the points through which the arch muſt paſs; but the Reader muſt recollect that four or five points will not be ſufficient in the practice for tracing the curve with accuracy, and therefore a greater number muſt be found. At the other end of the groin is ſhewn the manner in which it may be fixed, ſufficiently intelligible for a workman.

PLATE XXIII.

A WELCH GROIN.

DEFINITION.

A Welch groin is an under pitch groin, whoſe ſide and body arches are both given ſemicircles, or they may be ſimilar ſegments of circles cutting through one another, whoſe interſections do not meet in a plane ſurface, that is, the place of the ribs will not be ſtraight upon the plan, but will generate a curve line.

Given the body rib A, *and the ſide rib* B, *of a Welch groin, to find a mould for the interſecting ribs.*

Divide half the arch *B* into any number of equal parts 1, 2, 3, *d*, or they may be taken at diſcretion, and from theſe points let fall perpendiculars to *a b*, its baſe; produce them at pleaſure; alſo from the ſame points 1, 2, 3, *d*, draw lines parallel to *a b*, the baſe of *B*, to interſect the perpendicular line *e f*; transfer the diviſions from *e f* to *e g*; then from the diviſion of *e g* draw lines parallel to *p q*, to interſect the body rib *A* at the points *h u w y*; from theſe points draw perpendiculars to *p q*, its baſe, and continue them to interſect with the perpendiculars from *B*, at the points *k*, *l*, *m*, *n*, between *C* and *D*; then trace a curve through theſe points, which will be the place of the interſecting ribs upon the plan; then draw two other curve lines on each ſide of *k*, *l*, *m*, *n*, &c. to make the thickneſs of the rib upon the plan; on the inſide of the curve draw two chords for each half to their extremities, draw two other lines parallel to them to touch the outſide curve, then the diſtance between thoſe two ſtraight lines will ſhew what thickneſs of ſtuff it will take to make the interſecting rib; through the points *k l m n*, &c. draw perpendicular lines to the chords, make the heights *c d*, 3 3, 2 2, 1 1, &c. at *D*, equal to their correſponding heights at *B*; then *D* is the mould for the interſecting rib; *C* is the ſame as *D*.

To bevel the ribs, ſo that they will ſtand perpendicular over the plan.

At the points *x v t i*, draw the parallel dotted lines to the ordinates of *C* and *D*, and make their correſponding heights equal to theſe of the arch *B* or *A*; draw the dotted curve line *h u w y* at *C*, and it will ſhew how much is to be bevelled off on that ſide of the rib; in like manner the other ſide *D* is bevelled, as is ſhewn by the dotted curve line.

To find a mould to bend under the interſecting ribs, ſo that it ſhall give the place of the angle truly upon the plan.

Take the ſtretch round the under ſide of the rib *D* at the dots, by bending a thin ſlip of wood round it, mark it at each dot, and ſtretch it out along the ſtraight line *b c* at *E*, draw the ordinates acroſs, and prick them from the plan that lies between *D* and *C*, then *E* agreeable to the letters will be the mould required.

Note. The ſtraight edge of the mould muſt be kept exactly to the face of the rib; when it is bent round, then draw a curve round the under ſide of the rib, by the other edge of the mould, will give the true place of the angle.

Plate 23.

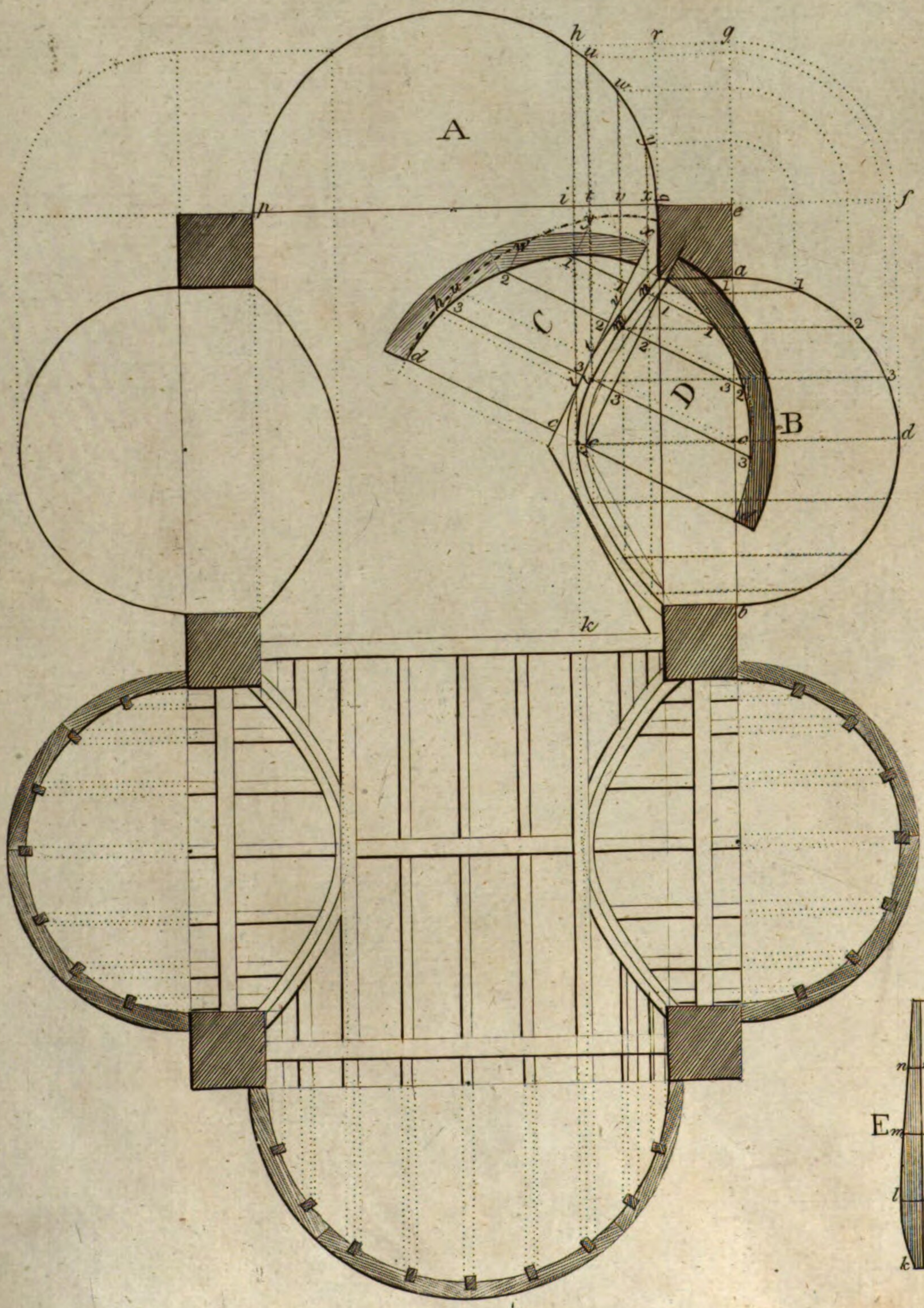


Plate 24.

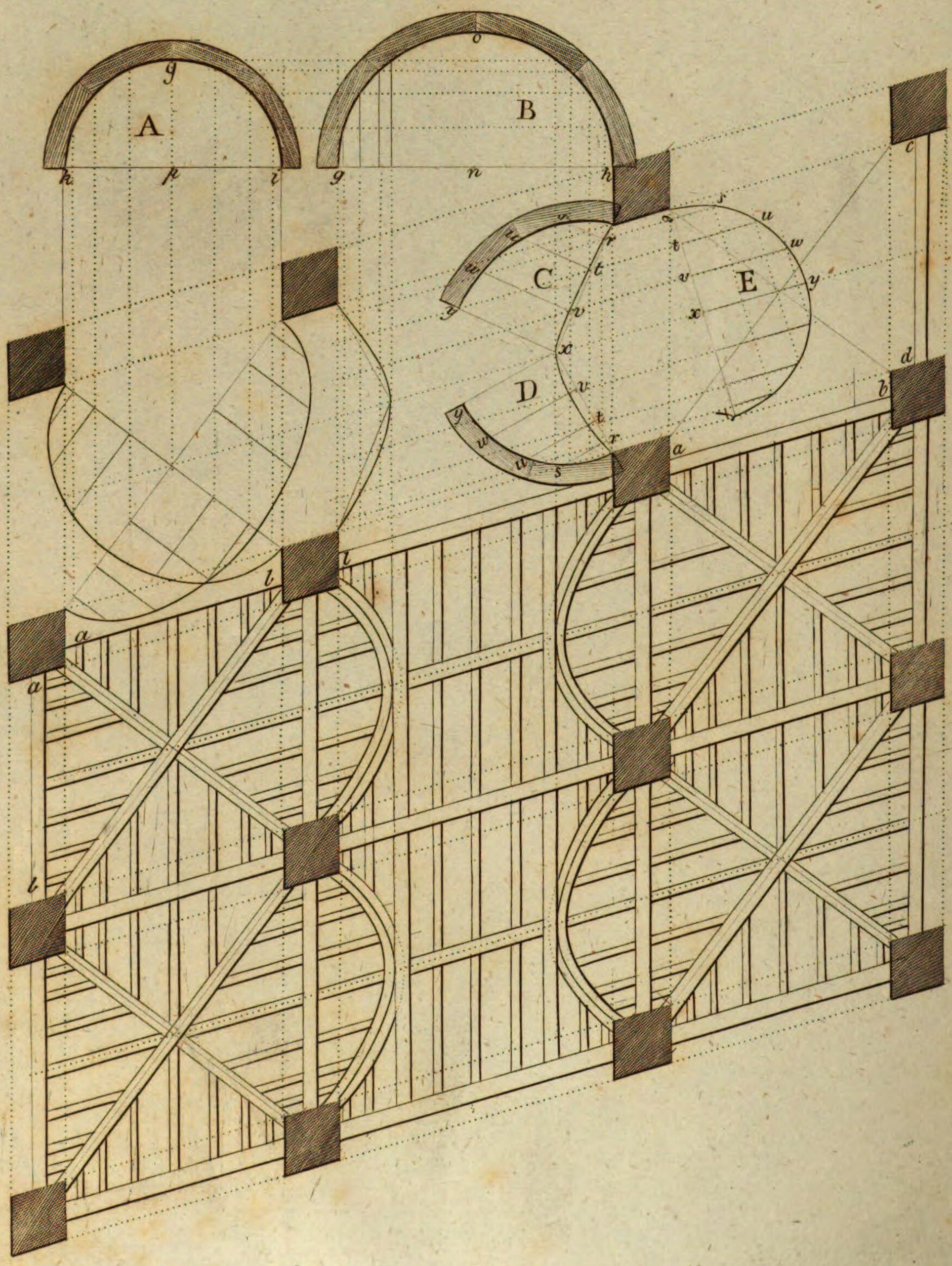


Plate 25.

Fig. A.

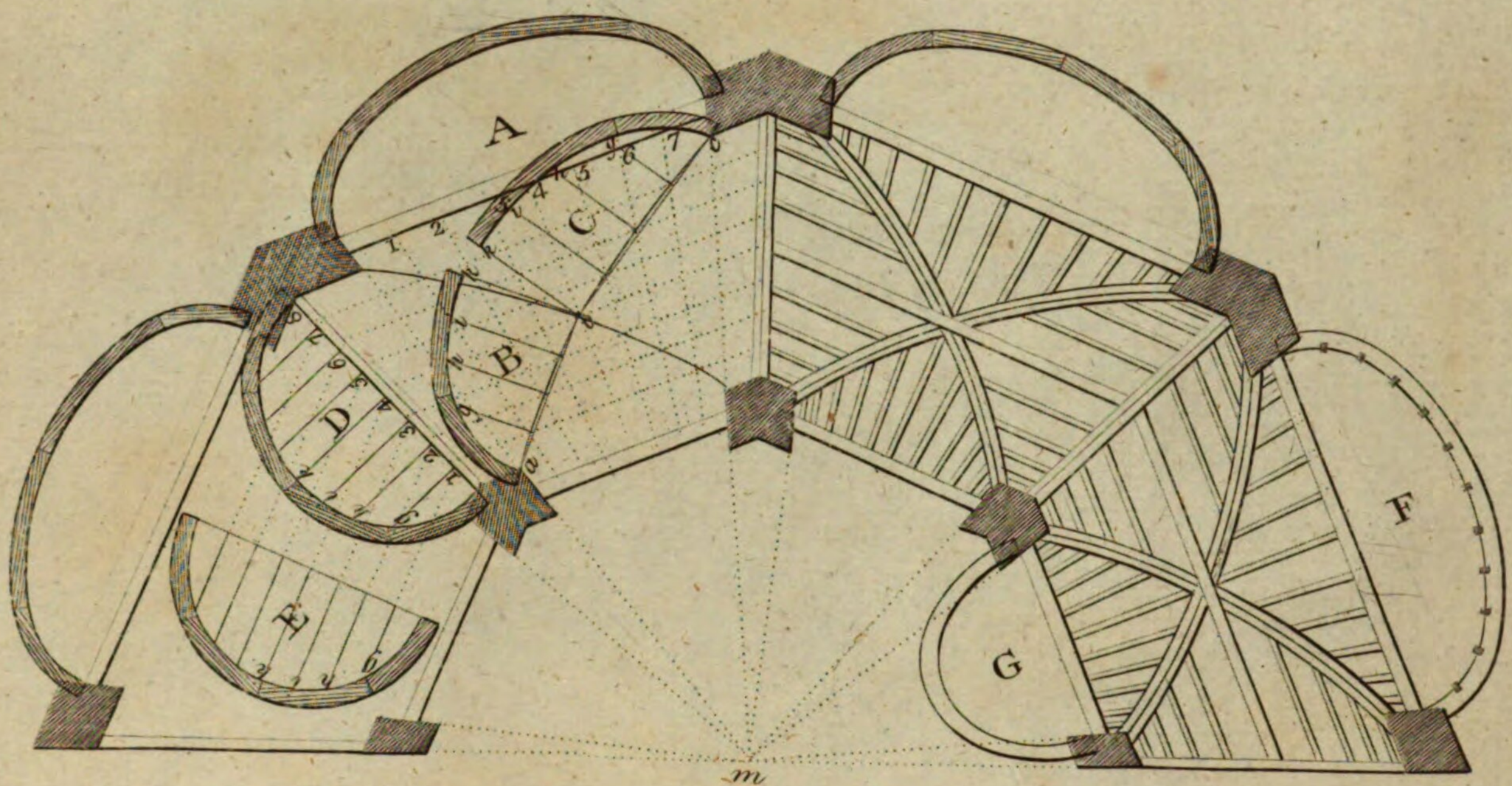


Fig. 2.

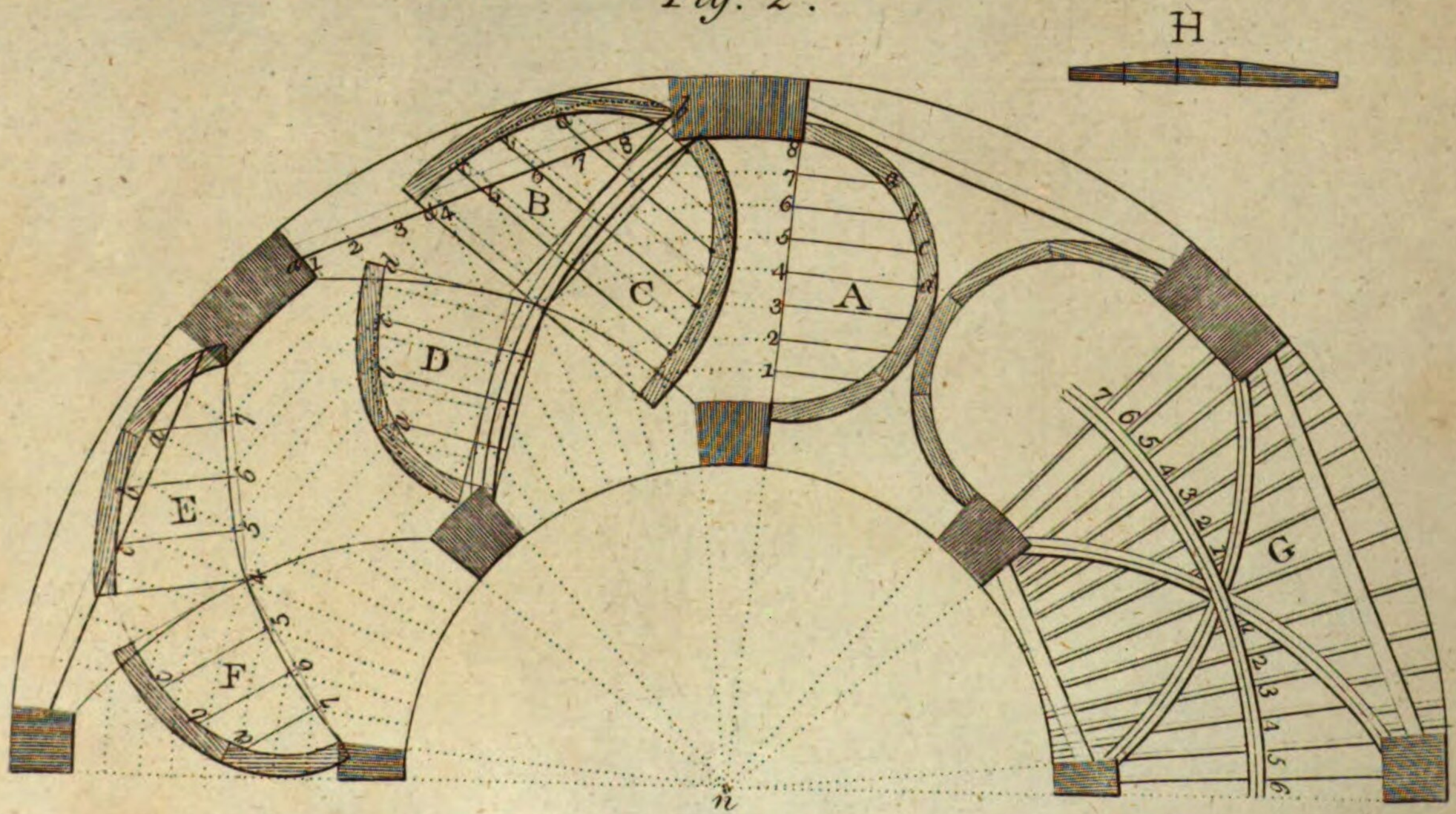


PLATE XXIV.

There will be no occaſion for explaining the lines of this groin, as they are of the ſame nature as thoſe in the laſt plate; but it will be proper to take notice, as this is a bevel groin, the ribs muſt lie in the ſame direction as the plan of the groin, which will make them longer than their correſponding given arches at the top, but of the ſame height; they are conſequently ellipſes, being the ſections of cylinders, therefore to make a rib over *l m* acroſs the two piers take the extent of the baſe *l m*, and the height of the given arch *n o*, and deſcribe an ellipſis; and to deſcribe the ſide arches between any two piers, as from *a* to *b*, take the extent *a b*, and the height of the given arch *p g*, at *A*, and deſcribe an ellipſis, it will give the proper form of the rib to ſtand over *a b*; the interſecting ribs will require two moulds *C* and *D*, owing to the groins being bevel upon the plan.

Note. The letters are marked the ſame upon *D* and *C* as they are upon *E*, to ſhew they are traced from it.

PLATE XXV.

To deſcribe the interſecting or angle ribs of a groin ſtanding upon an octagon plan, the ſide and body ribs being given both to the ſame height.

FIG. 1. *E* is a given body rib which may be either a ſemicircle or a ſemi-ellipſis, and *A* is a ſide rib given of the ſame height; *D* is a rib acroſs the angles, trace from *E*, the baſis of both being divided into a like number of equal parts, divide the baſe of the given rib *A*, into the ſame number of parts; from theſe points draw lines acroſs the groin to its centre at *m*, and from the diviſions of the baſe of the other rib *D*, draw lines parallel to the ſide of the groin, then trace the angle lines through theſe ſquares, will be the place of the interſecting ribs, draw the chords *a b*, and *b c*, then prick the moulds *B* and *C* from *E* or *D*, but take care not to prick them from the crooked line at the baſe, but from the ſtraight chords *a b*, and *b c*.

To deſcribe and back the angle ribs of a groin circular upon the plan, the ſide and body arches being given, as in the laſt groin.

The ribs are deſcribed in the ſame manner as in the laſt example for the octagon groin, or in the ſame manner as the Welch groin, plate 23, and the backing or bevelling is found in the ſame manner as is deſcribed in that plate.

Note. *E* and *F* are the ſame moulds as are ſhewn at *B* and *D*.

PLATE

PLATE XXVI.

The ſide rib A, *and the angles being given ſtraight upon the plan, to find the angle rib* C, *and the body rib* C.

FIG. 1. The rib *A* is ſuppoſed to be placed over the ſtraight line *a b*, and its baſe divided into any number of equal parts, as 8 ; from the diviſions draw lines to the centre of the groin, to interſect the angles at the points *a b c d e f g* ; place the foot of your compaſs in the centre of the groin, and from the points *a b c d*, &c. draw lines to the baſe of *C*, and make the ordinates of *C* equal to thoſe of *A*, then *C* is the body rib ; draw lines at right angles from the points *a b c d*, &c. and prick the moulds *G* and *B* from *A*, will be the angle ribs required ; this wants no mould to bend under the angle rib, as in the others that are crooked upon the plan.

How to deſcribe the ribs of a groin over ſtairs upon a circular plan, the body rib being given.

FIG. 2. Take the tread of as many ſteps as you pleaſe, ſuppoſe nine, from *E*, and the heights correſponding to them, which lay down at *F* ; draw the plan of the angles as in the other groins, and take the ſtretch round the middle of the ſteps at *E*, and lay it from *a* to *b* at *F*; make *d e* perpendicular to *b c* at *B*, equal to *d e* at *F*, draw the hypotenuſe *e c*, draw perpendiculars from *d c* up to *B*, and prick *B* from *A*, as the figures direct, then *B* is the mould to ſtand over *a b* ; draw the chords *a* 4, and 4 *m* at the angles, make *a* 9, 4 *h*, perpendicular to them, each equal to half the height *d e*, at *B* or *F*, draw the hypotenuſe *g* 4, and *h m*, draw the perpendicular ordinates from the chords through the interſection of the other lines that meet at the angles, then trace the moulds *D* and *C*, from the given rib *A*, will form the moulds for the angle or interſecting ribs.

Note. The reaſon that the angle ribs *D* and *C* are laid contrary ways, is only to avoid confuſion.

PLATE

Plate 26.

Fig. 1.

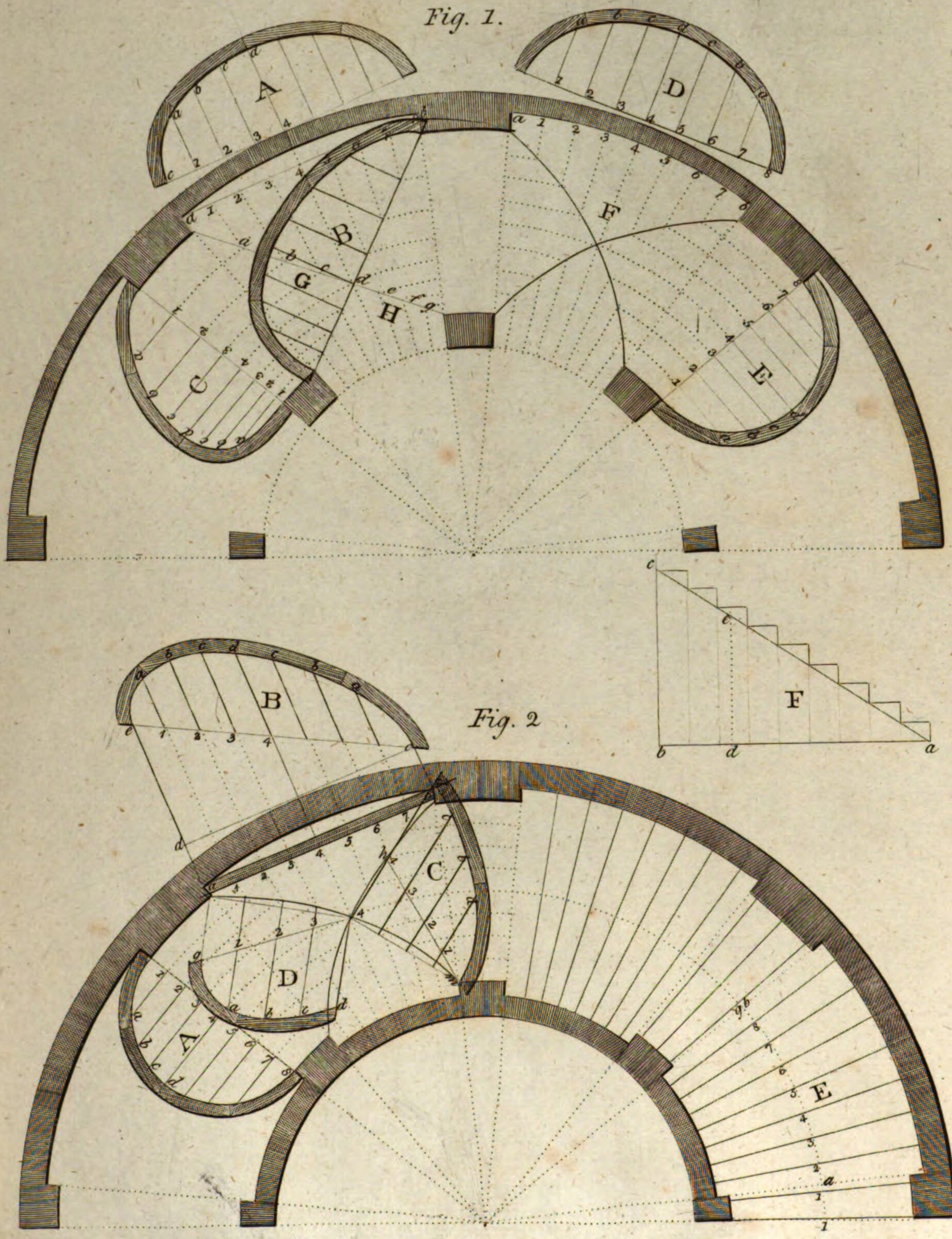
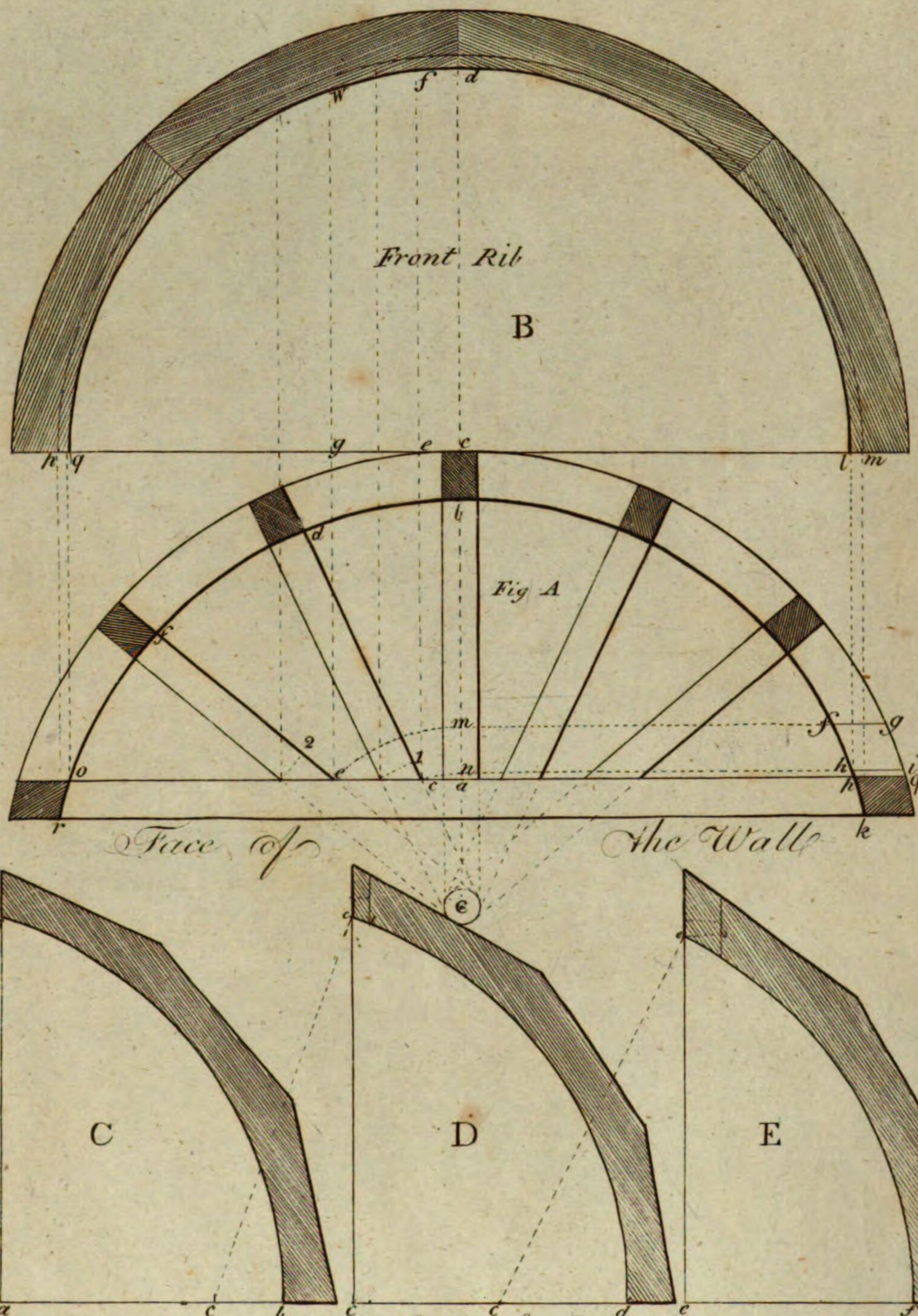


Fig. 2

Plate 27.



Pub.d as the Act directs Sep.r 4. 1792. by P Nicholson.

PLATE XXVII.

As the ſurface of a globe is every where of the ſame curvature, conſequently the ſurface of any ſegment of a globe, or part, muſt ſtill retain the ſame curve as before it was cut; and for this reaſon, it appears that the curves of the back ribs of a niche muſt be the ſame ſweep as the ground plan itſelf; and the front rib is a ſemicircle. See Axiom the 3d, page 14, and figure 1, plate 10. If a ſemi-globe is cut by a plane at right angles to the plane of its baſe, then the ſection is a ſemicircle. The practice of this is eaſy.

To get out the ribs for the head.

From the centre *c* draw the ground plan of the ribs as at *figure A*, and ſet out as many ribs upon the plan as you intend to have in the head of the niche, and draw them all out towards the centre at *c*. Place the foot of your compaſs in the centre *c*, and from the ends of each rib, at *e* and *c*, draw the ſmall concentric dotted circles round to the centre rib at *m* and *n*; then draw *m g* and *n i*, parallel to *r k*, the face of the wall; then from *q* round to *e* upon the plan, is the length and ſweep of the centre rib, to ſtand over *a b*; and from *i* round to *e*, the length and ſweep of the rib that ſtands from *c* to *d* upon the plan; and from *g* round to *e* is the ſweep of the ſhorteſt rib, that ſtands from *e* to *f* upon the plan.

How to bevel the ends of the back ribs againſt the front rib.

The back ribs are laid down diſtinct by themſelves at *C D* and *E*, from the plan. Take *c* 1, in *figure A*, and ſet it from *c* to 1 in *D*, will give the bevel of the top of the rib *D*. And from *figure A*, take from *e* to 2 upon the plan, and ſet it from *e* to 2 in the rib *E*, will give the bevel of the top.

To find the places of the back ribs where they are fixed upon the front.

From the points *a c* and *e*, at the ends of the ribs, in the plan, *figure A*, draw the dotted lines up to the front rib, to *d f* and *w*, which will ſhew where they are to be fixed upon the front rib. The double circle upon the front rib ſhews the backing.

PLATE XXVIII.

To find the curve of the ribs of a globular niche, the plan and elevation being given ſegments of circles.

In *fig. A* is the elevation of the niche, being the ſegment of a circle whoſe centre is *t*, at *B* is the plan of the ſame width, and may be made to any depth, according to the place it is intended for, and its centre is *c*; on the plan *B*, lay out as many ribs as you think it will take, draw them all tending to the centre at *c*, they will cut the plan of the front rib in *g f e d*; through the centre *c*, draw the line *m n*, parallel to *a b*, the plan of the front rib; put the foot of your compaſs in the centre at *c*, draw the circular lines from *a*, *g*, *f*, *e*, *d*, to the line *m n*, and make *c s* equal to *u t*, that is, make the diſtance from the middle of the chord line *m n* to *s*, the centre of the arch at *C*, equal to the diſtance from the middle of the chord of the top at *fig. A*, to its centre at *t*; then place the foot of your compaſs in *s*, as a centre, and from the extremities *m* or *n*, deſcribe the arch at *C*, with the ſame centre draw another line parallel to it, to any breadth as you intend your ribs ſhall be, then *C* is the true ſweep of all the back ribs in the niche.

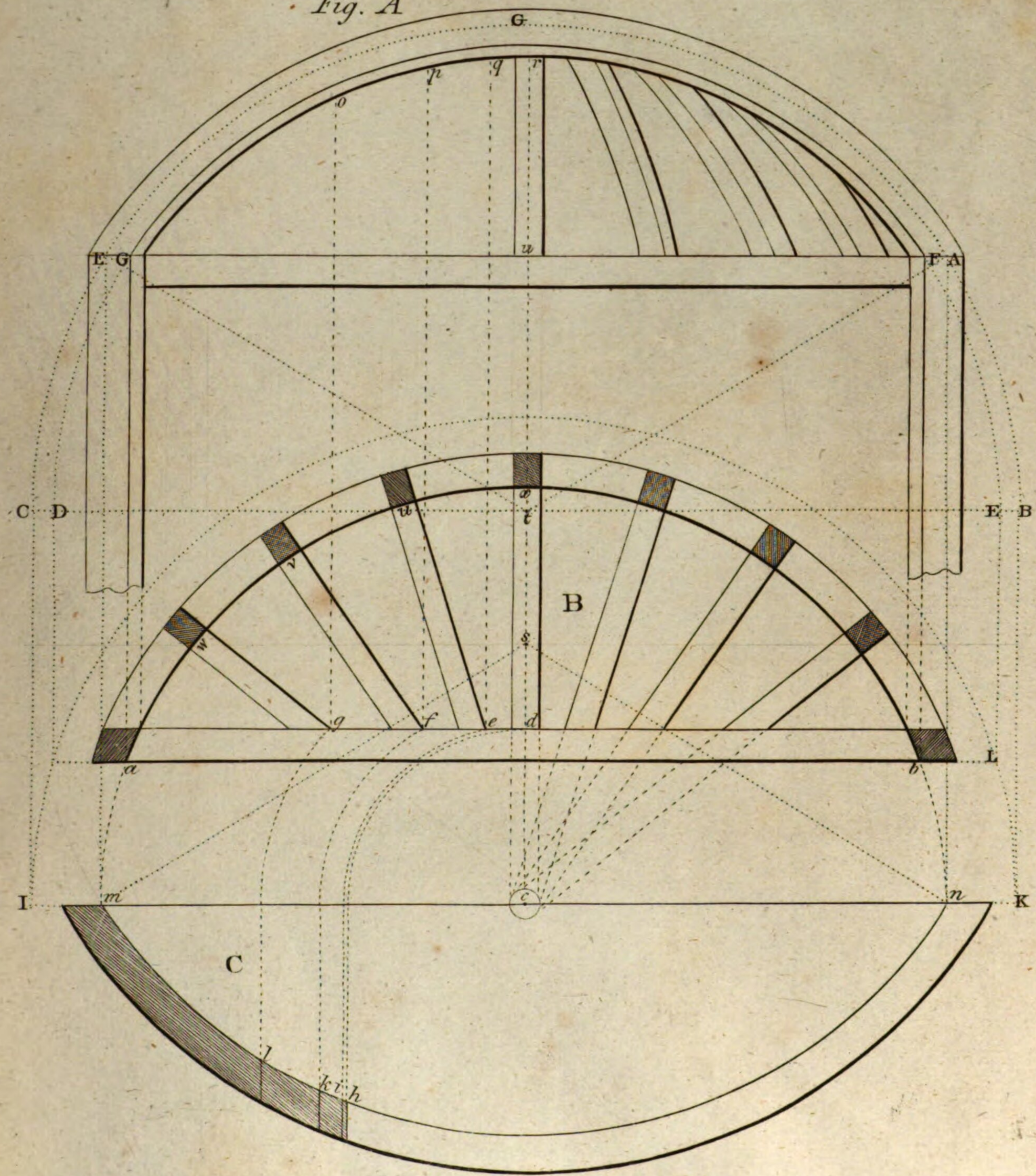
Note. The points *l k i h*, ſhew what length of each rib will be ſufficient from the point *m*; from *h* to *m* is the rib that will ſtand over *d x*, from *i* to *m* is the rib that will ſtand over *e u*, from *k* to *m* over *f v*, and from *l* to *m* over *g w*; the other half is the ſame.

The truth of this is eaſy to be conceived by thoſe who have previouſly ſtudied the Sections of a Globe, in plate 10 of this book.

Through the centre *t*, draw D E, parallel to *a b*, complete the ſweep of the top, G F, to the line D E, then D E is the diameter; through *n* draw *n* A parallel to *u d*, in the centre *t*; with the diſtance *t* A deſcribe another ſemicircle, whoſe diameter is *c b*; then will the ſemicircle C F G A B, be equal to a vertical ſection of the globe, ſtanding on I K, paſſing through its centre at *c*, which is the ſame ſweep as the rib at *C*, becauſe *u* A is equal to *c n*, and *c s*; biſecting *m n* at right angles, is equal to *t u*, biſecting E A at right angles; therefore the hypotenuſe *t* A, that is, the radius of the circle B A G E C, is equal to *s n*, the radius of the circle or rib at *C*.

Plate 28

Fig. A



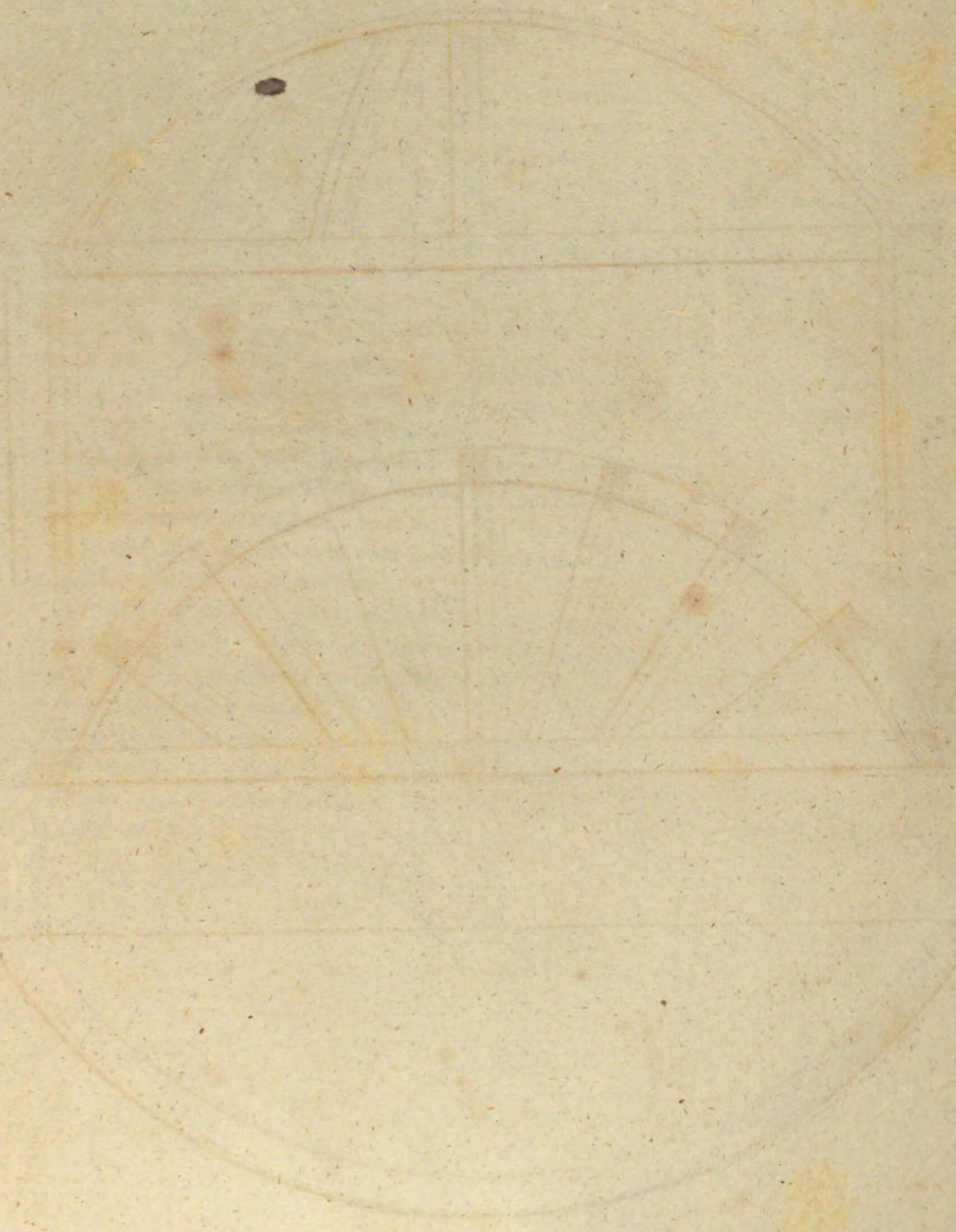


Plate 29.

Fig. A

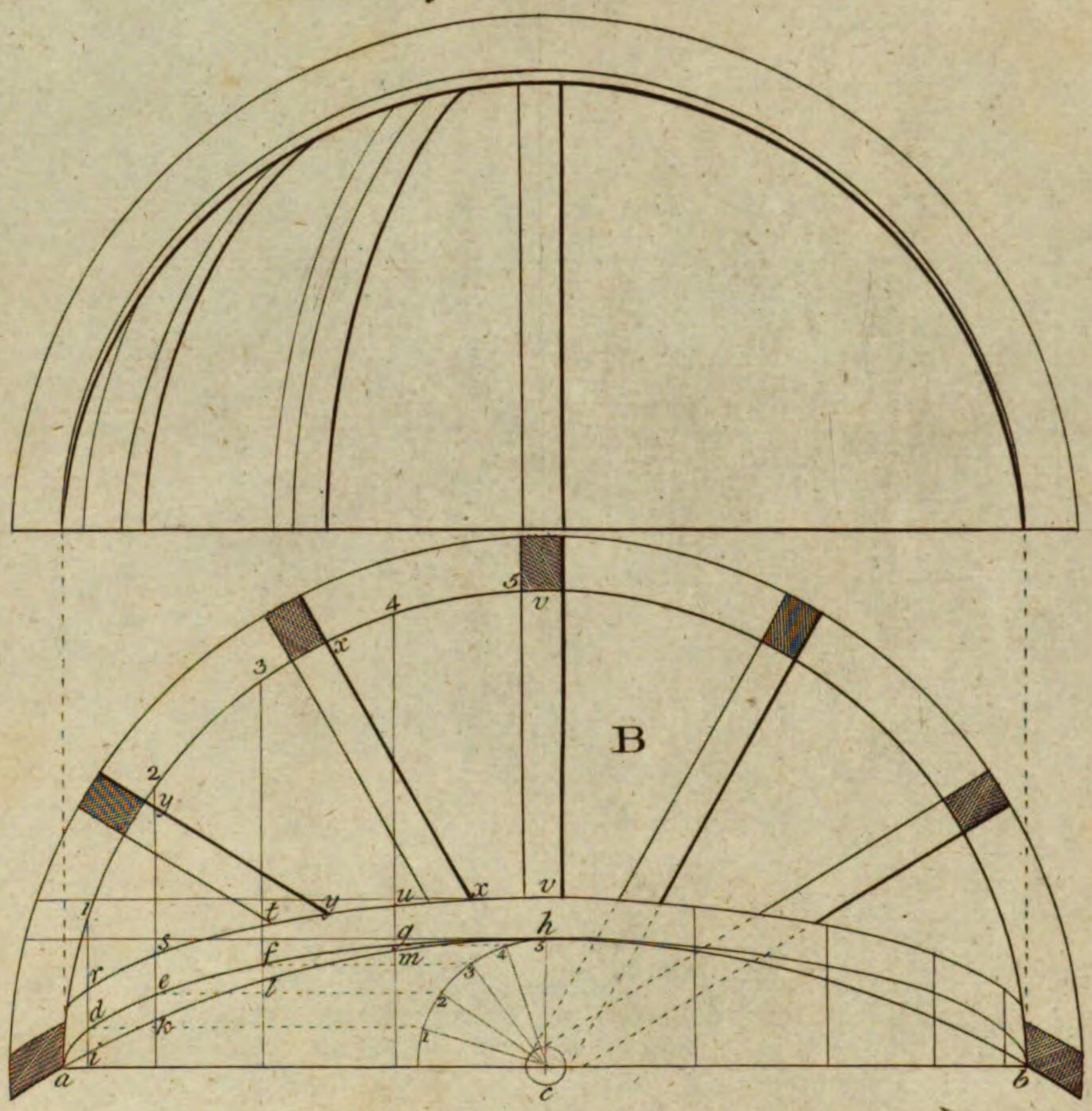


PLATE XXIX.

The plan of a niche being given, ſtanding in a circular wall, to find the front rib.

B is the plan given, which is a ſemicircle whoſe diameter is *a b*, and *a*, *i*, *k*, *l*, *m*, *h*, the front of the circular wall; ſuppoſe the ſemicircle *B* to be turned round its diameter *a b*, ſo that the point *v* may ſtand perpendicular over *h* in the front of the wall, the ſeat of the ſemicircle ſtanding in this poſition upon the plan will be an ellipſis; therefore divide half the arch *B* upon the plan into any number of equal parts, as 5; draw the perpendiculars 1 *d*, 2 *e*, 3 *f*, 4 *g*, 5 *h*, upon the centre *c* with the radius *c h*, deſcribe the quadrant of a ſmaller circle, which divide into the ſame number of equal parts as are round *B*; through the points 1, 2, 3, 4, 5, draw parallel lines to *a b*, to interſect the others at the points *d*, *e*, *f*, *g*, *h*; through theſe points draw a curve, it will be an ellipſis; then take the ſtretch out of the rib *B*, round 1, 2, 3, 4, 5, and lay the diviſions double at *F*, ſtretched out; take the ſame diſtances *d i*, *e k*, *f l*, *g m*, from the plan, and at *F* make *d i*, *e k*, *f l*, equal to them, which will give a mould to bend under the front rib, ſo that the edge of the front rib will be perpendicular *a*, *i*, *k*, *l*, *m*.

Note. The ſweep of the front rib is a ſemicircle, the ſame as the ground plan, and the back ribs at *C D* and *E* are likewiſe of the ſame ſweep.

The reaſon of this is eaſy, the niche being part of a globe, the curvature muſt be every where of the ſame ſweep, and conſequently the ribs fit upon that curvature.

Note. The curve of the mould *F* will not be exactly true, as the diſtances *d i*, *e k*, *f l*, &c. are rather too ſhort for the ſame correſponding diſtances upon the ſoffit at *F*, but in practice it will be ſufficiently near for plaiſter work; but thoſe who would wiſh to ſee a method more exact, may examine plate 15, *fig. A*, where *C* is the exact ſoffit that will bend over its plan at *B*.

In applying the mould *F* when bent round the under edge of the front rib, the ſtraight ſide of the mould *F* muſt be kept cloſe to the back edge of the front rib, and the rib being drawn by the other edge of the mould, will give its place over the plan.

PLATE XXX.

The plan and elevation of an elliptic niche being given, to find the ſweep of the ribs.

FIG. *A.* Deſcribe every rib with a trammel, by taking the extent of each baſe from the plan whereon the ribs ſtand to its centre, and the height of each rib to the height of the top of the niche, it will give the true ſweep of each rib.

To back the ribs of the niche.

There will be no occaſion for making any moulds for theſe ribs, but make the ribs themſelves; then there will be two ribs of each kind; take the ſmall diſtances 1 *e*, 2 *d*, from the plan at *B*, and put it to the bottom of the ribs *D* and *E*, from *d* to 2, and *e* to 1; then the backing may be drawn off by the other correſponding rib; or the backing may be drawn off with the trammel, as for example at the rib *E*, by moving the centre of the trammel towards *e*, upon the line *e c*, from the centre *c*, equal to the diſtance 1 *e*, the trammel rod remaining the ſame as when the inſide of the curve was ſtruck.

Given one of the common ribs of a cove bracket, to find the angle bracket for a ſquare or rectangular room. FIG. *H.*

Let *H* be the common bracket, *b c* its baſe; draw *b a* perpendicular to *b c*, and equal to it, draw the hypotenuſe *a c*, which will be the place of the mitre; take any number of ordinates in *H*, perpendicular to *b c*, its baſe, and continue them to meet the mitre line *a c*, that is, the baſe of the bracket at *I*; draw the ordinates of *I* at right angles to its baſe; then the bracket at *I*, being pricked from *H*, as may be ſeen by the figures, will be the form of the angle rib required.

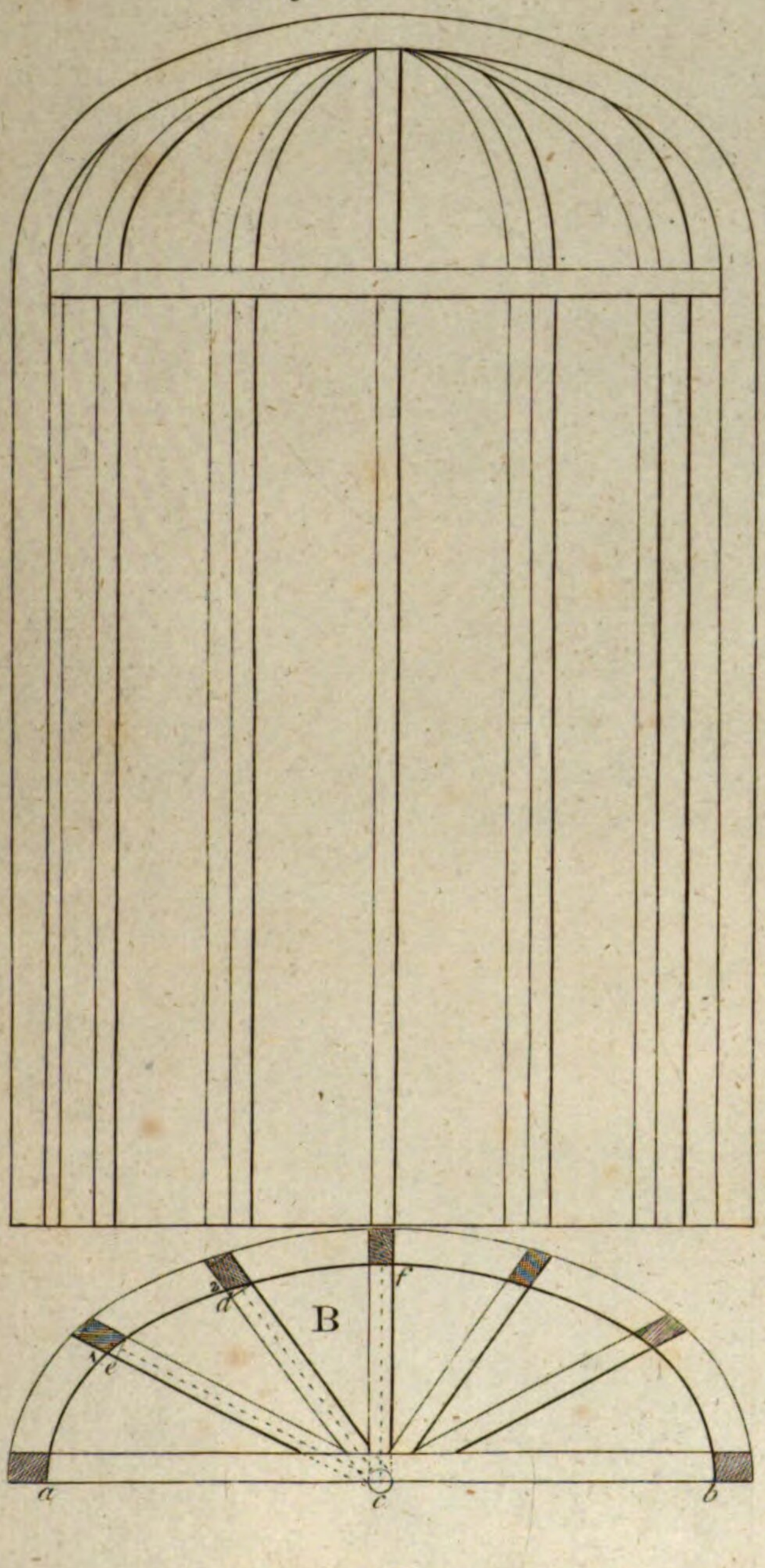
Note. The angle rib muſt be backed either externally or internally, according to the angle of the room.

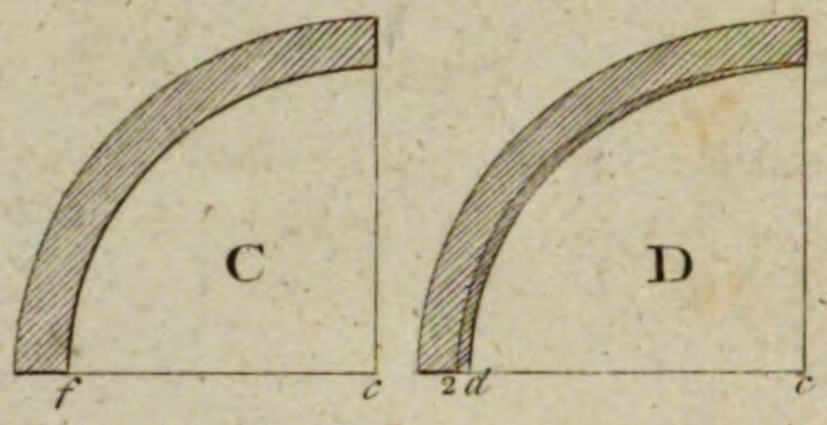
Having given a common bracket K, *ſee fig.* G, *for plaiſter, to find the mitre bracket* L.

Proceed as in the laſt example, and you will have the bracket required.

Plate 30.

Fig. A





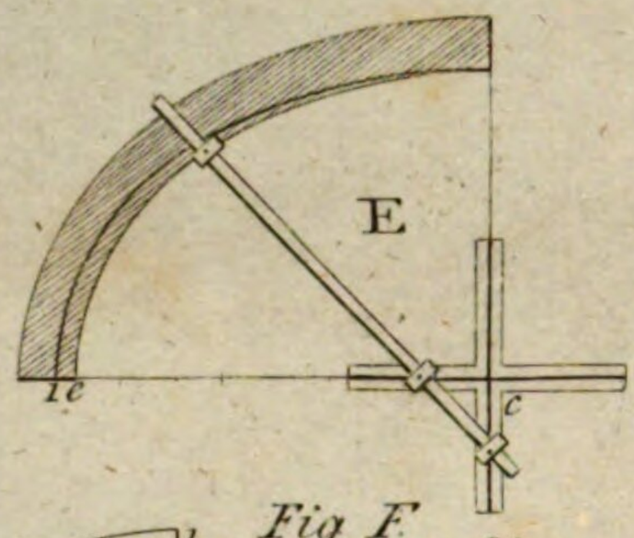


Fig F

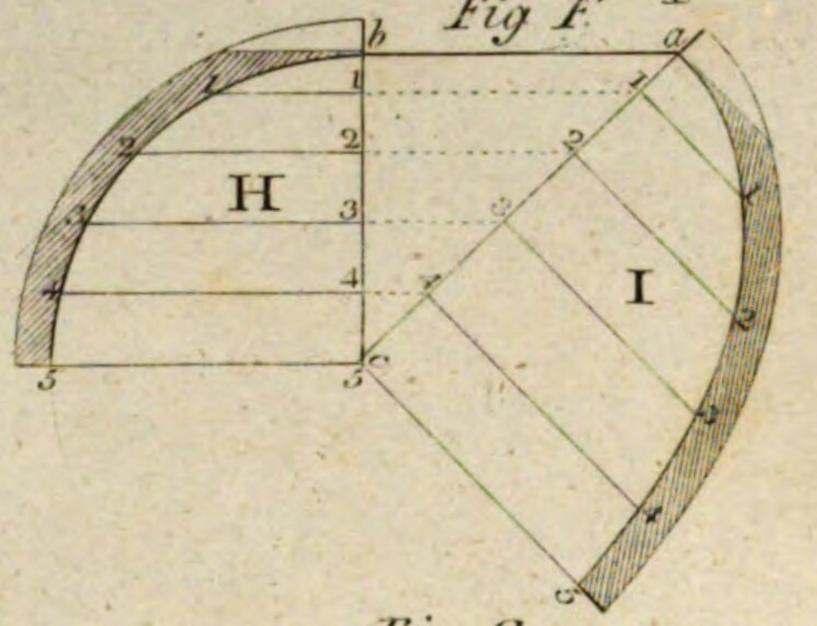


Fig G

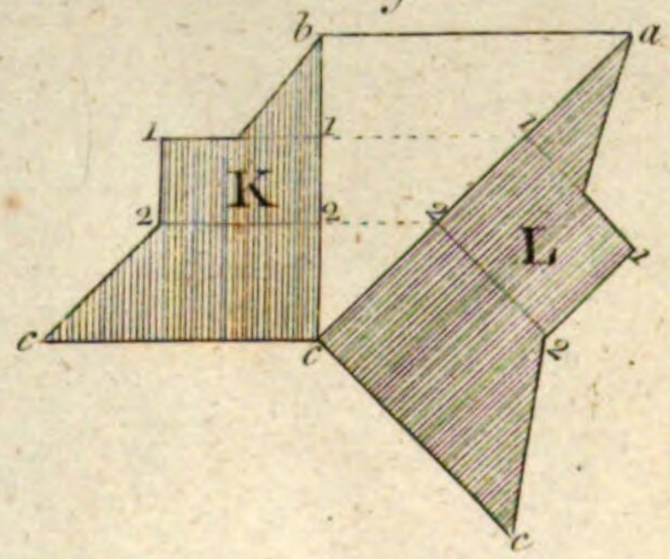


Plate. 31.

Fig. A.

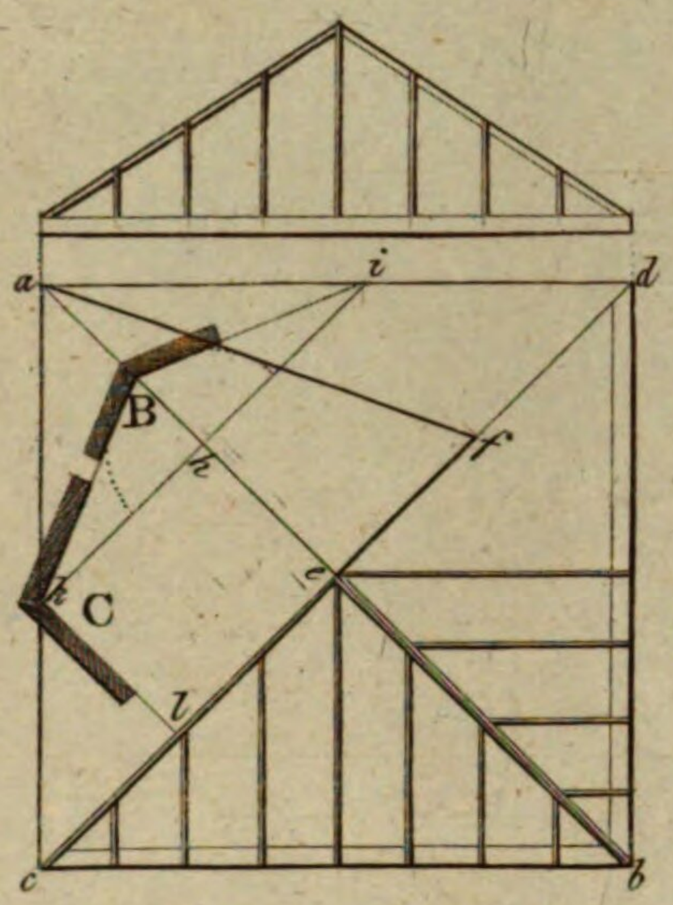


Fig. B.

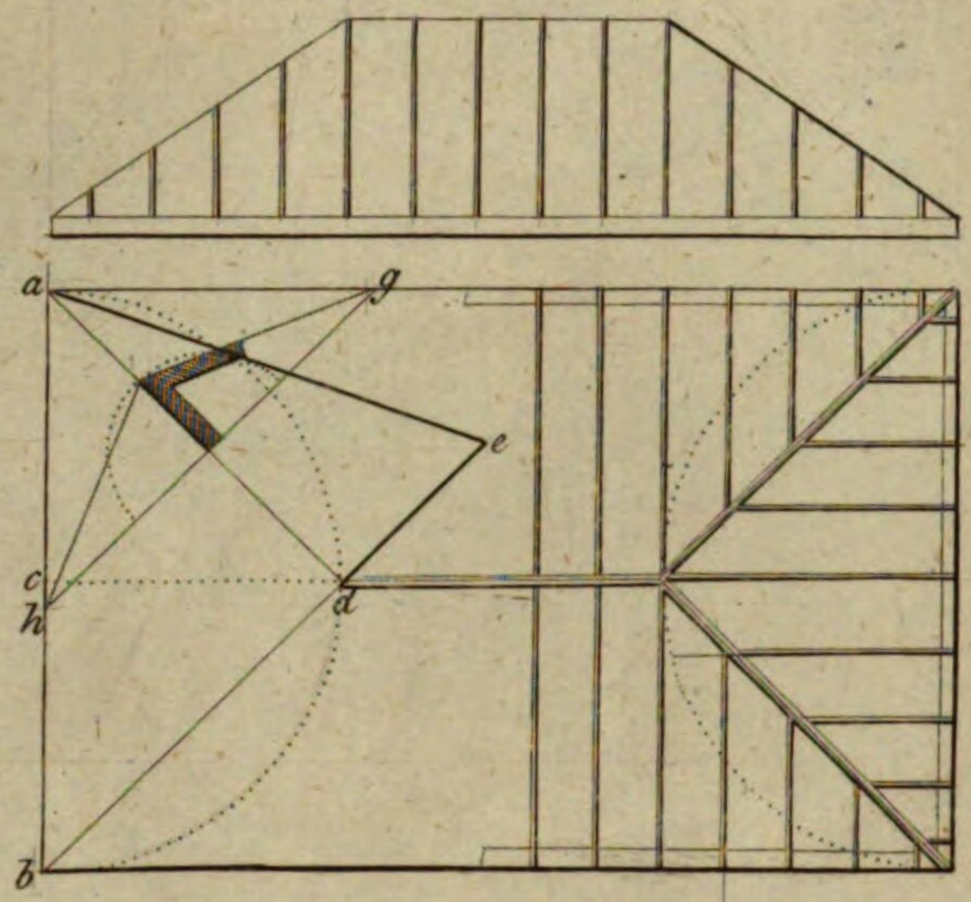


Fig. C.

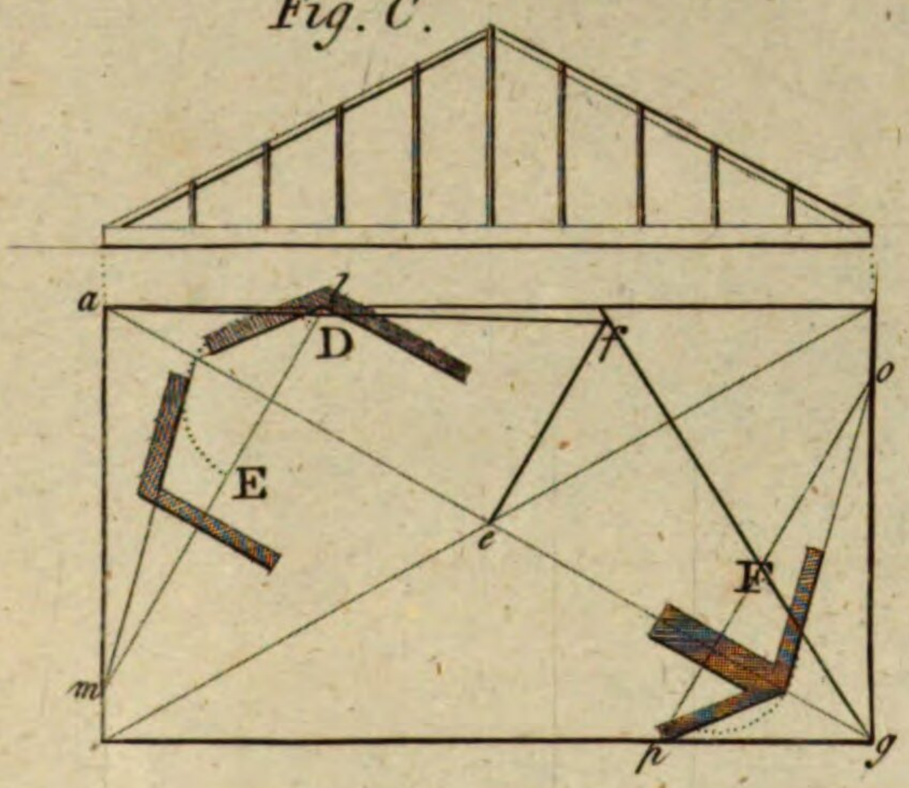


Fig. D.

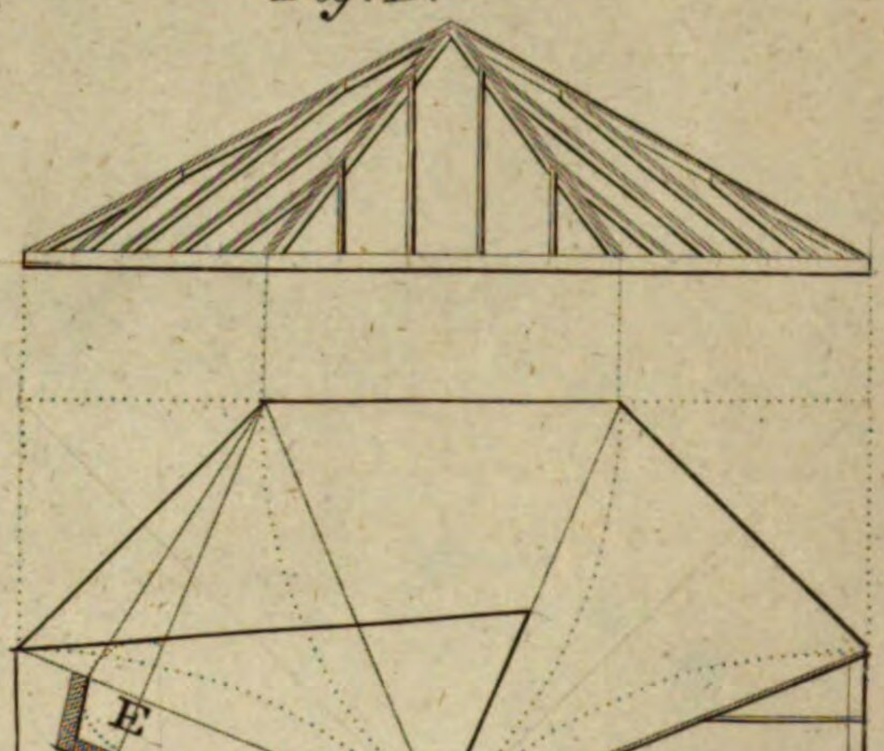


Fig. E.

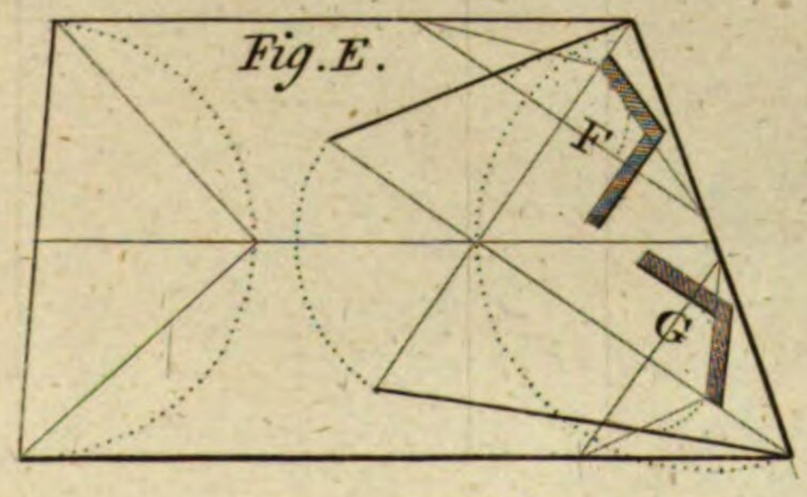


PLATE XXXI.

SKY-LIGHTS.

To find the length of the hips of a ſky-light ſtanding upon a ſquare plan, the height being given.

In *fig. A*, draw the diagonals *a b*, and *c d*; they will biſect each other at right angles at *e*; take *a e* for the baſe of any hip; from *e* make *e f* equal to the height of the ſky-light; from *a* to *f* draw a line *a f*, it will be the length of the hip required.

To find the backing of the hip.

Draw any line *k i*, at right angles to *a e*, the baſe of the hip rafter, to cut it in any point *h*, put the foot of your compaſs in *h*, as a centre, and with the other deſcribe a circle to touch *a f*, the hip rafter, to cut the baſe line *a e*, at *g*; then draw *g i* and *g k*; then the angle *k g i* will be the backing of the hip, as is ſhewn by the bevel at *B*; but the beſt way to work the hips is to apply a bevel to the parallel ſides of the hips, as is ſhewn at *C*, by making the other ſide of the bevel parallel to *a e*, the baſe of the hip.

Note. The ſame lines will extend to any ſky-light, whatever may be the form of its plan; if it be any polygon, to find the length of the hip rafter, draw a line through any point in its baſe at right angles to it, ſo as to cut the two contiguous ſides to that baſe, and on the ſaid point as a centre deſcribe a circle to touch the hip rafter from the point where this circle cuts the baſe line, draw two lines to meet the ends of the perpendicular line at the ſides of the polygon; then the angle formed by theſe two lines will be the backing required: but perhaps a few more examples will make it plainer than many words can.

FIG. *B* is a ſky-light, ſtanding upon a rectangular baſe, having a ridge in the middle; make *c d* upon the ridge line equal to half the width of *a b*; then the angle *b d a* will be a right angle; every other requiſite is the ſame as directed for *fig. A*; if theſe hips are to be mitred, the bevel at *C* ſhews the mitre.

FIG. *C* is another ſky-light, ſtanding alſo upon a rectangular baſe; but the hips all meet over the centre of the plan at *e*, and conſequently the diagonals do not biſect each other at right angles; therefore take any baſe line as *a e*, or *e g*, and make *e f* perpendicular to *a e*, from *e*, and equal to the height of the ſky-light; and draw *f a*, or *f g*, for the length of the hip, by drawing the line *l m* at right angles to *a e*. The backing will be found in the ſame manner as the others above. This ſky-light will require two different bevels *D* and *E*, to be applied to the parallel ſides of the hip, which are both found from the backing by drawing the ſtocks of the bevel parallel to *a e*, the baſe of the hip.

But if the hips are to be mitred together, *F* and *G* ſhew the two bevels for the mitring each half, ſo that when put together ſhall form the proper backing.

FIG. *D* is a ſky-light ſtanding upon an octangular plan, as is deſcribed in *fig.* 8, plate 6, of the Geometry; the lengths of the hips and backing of the angle are found in the ſame manner as directed for others.

FIG. *E* is a ſky-light whoſe plan is a trapaziod; upon each end as a diameter deſcribe a ſemicircle to cut the ridge-line, from theſe points draw lines to the extremities of their reſpective diameters, which will form a right angle for the baſe of the hips to ſtand upon the backing or mitring of the hips, will be found as is deſcribed in *fig. A* and *B*.

PLATE XXXII.

LINES FOR ROOFING.

The lines for roofing are found in the ſame manner as the ſky-lights in the laſt plate; the length and backing of the hip muſt be found in the ſame manner as directed for the ſky-lights; and if it is required to find the end of a horizontal bar, ſo that it ſhall fit againſt the hip, it will be found in the ſame manner as finding the form of the end of a purline, ſo as to fit againſt the ſide of a hip rafter, which method will be deſcribed below: the ſame may be ſaid of the jack bars to be fitted againſt the hip of a ſky-light as in a roof.

In this plate one end of the roof is ſhewn in order to ſhew two caſes: the firſt is when the purline lies level, or having two ſides parallel to the horizon; the ſquare at *B*, and the bevel at *C*, will ſhew how to draw the end of the purline in this eaſy caſe; but the following method is univerſal in all poſitions of the purline.

Note. There will be no occaſion to draw this at large; as the bevels will be the ſame if done to ever ſo ſmall a ſcale, and the ſides may be meaſured from a ſcale.

Let *a b* be the width of a ſquare roof, make *b f* or *a e* one half of the width, and make *c d* perpendicular in the middle of *e f*, the height of the roof, which is here one third, and draw *d e*, and *d f*, which are each the length of a common rafter.

To find the bevels of a purline againſt the hip rafter.

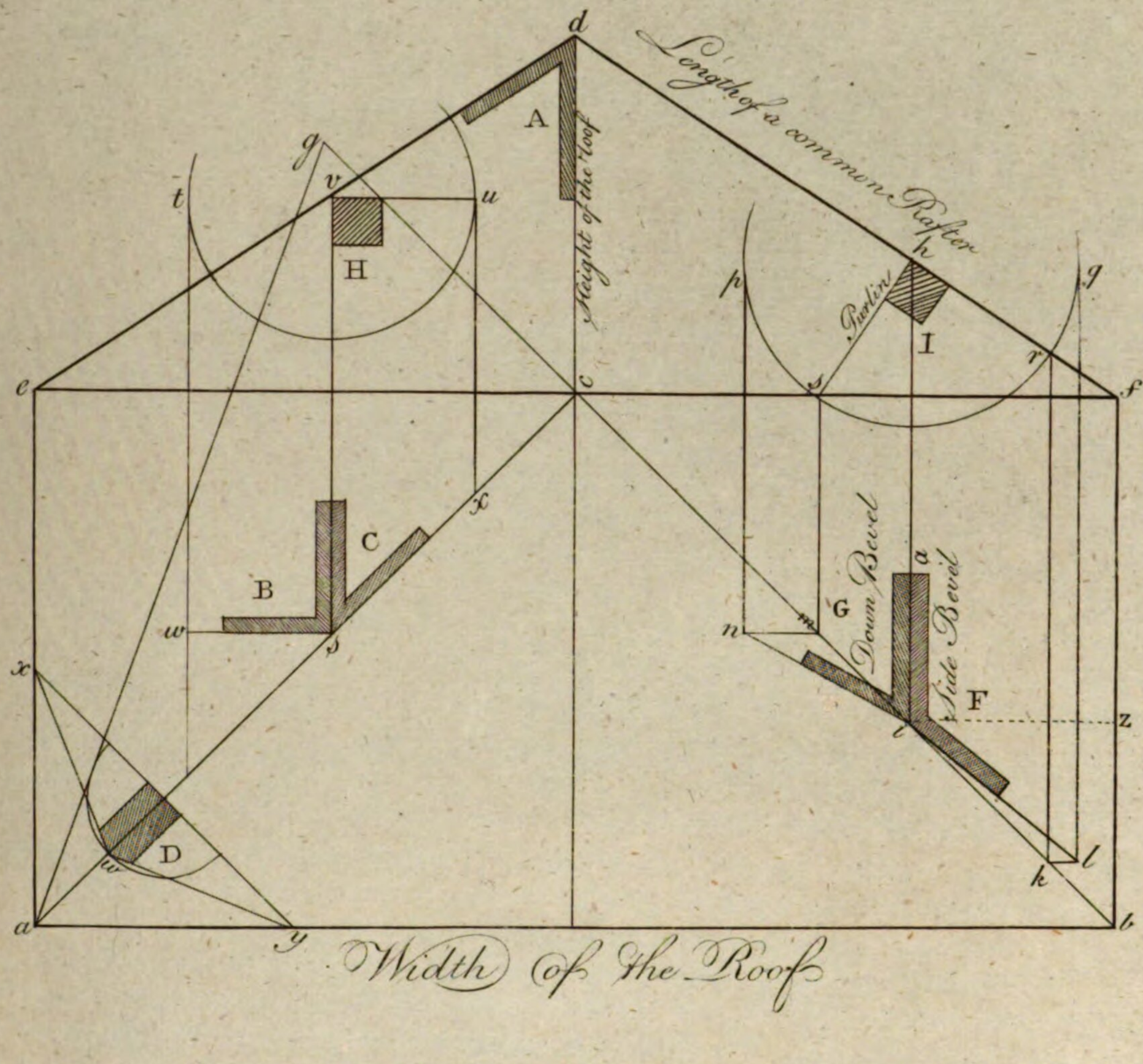
Let the purline be in any place of the rafter, as at *I*, and in its moſt common poſition, that is, to ſtand ſquare, or at right angles to the rafter; and from the point *h*, as a centre with any radius, deſcribe a circle. Draw two lines *q l*, and *p n*, to touch the circle in *p* and *q*, parallel to *f b*; and at the points *s* and *r*, where the circle and two ſides of the purline interſect, draw two parallel lines to the former, to cut the diagonal in *m* and *k*; and draw *m n* and *k l* perpendicular to *f m* and *r k*, and join the points *n i* and *k i*; then *G* is the down bevel, and *F* the ſide bevel of a purline: theſe two bevels, when applied to the end of the purline, and when cut by them, will exactly fit the ſide hip rafter.

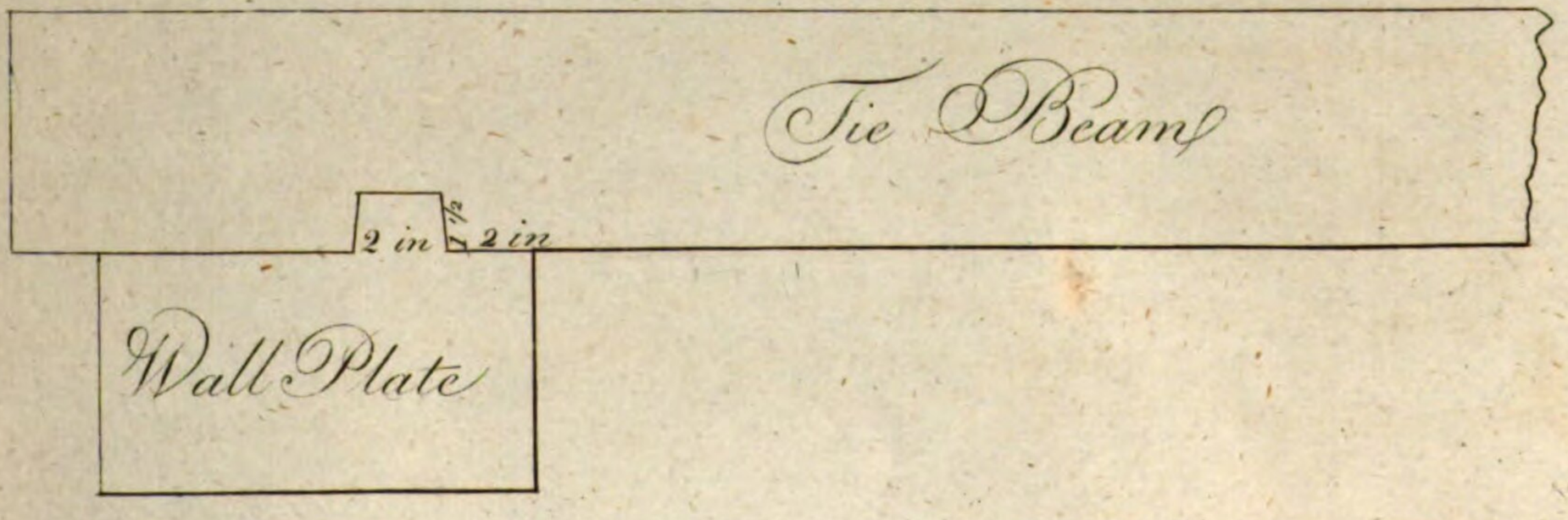
To find the bevels of a jack rafter againſt the hip.

By turning the ſtock of the ſide bevel of the purline, at *F*, from *a*, round to the line *i z*, will give the ſide bevel of the jack rafter. And the bevel at *A*, that is, the top of a common rafter, is the down bevel of the jack rafter.

At the bottom is ſhewn the manner of cocking down the tie beam upon the wall plate; the proper ſize of the cocking is figured at *a*.

Plate 32.





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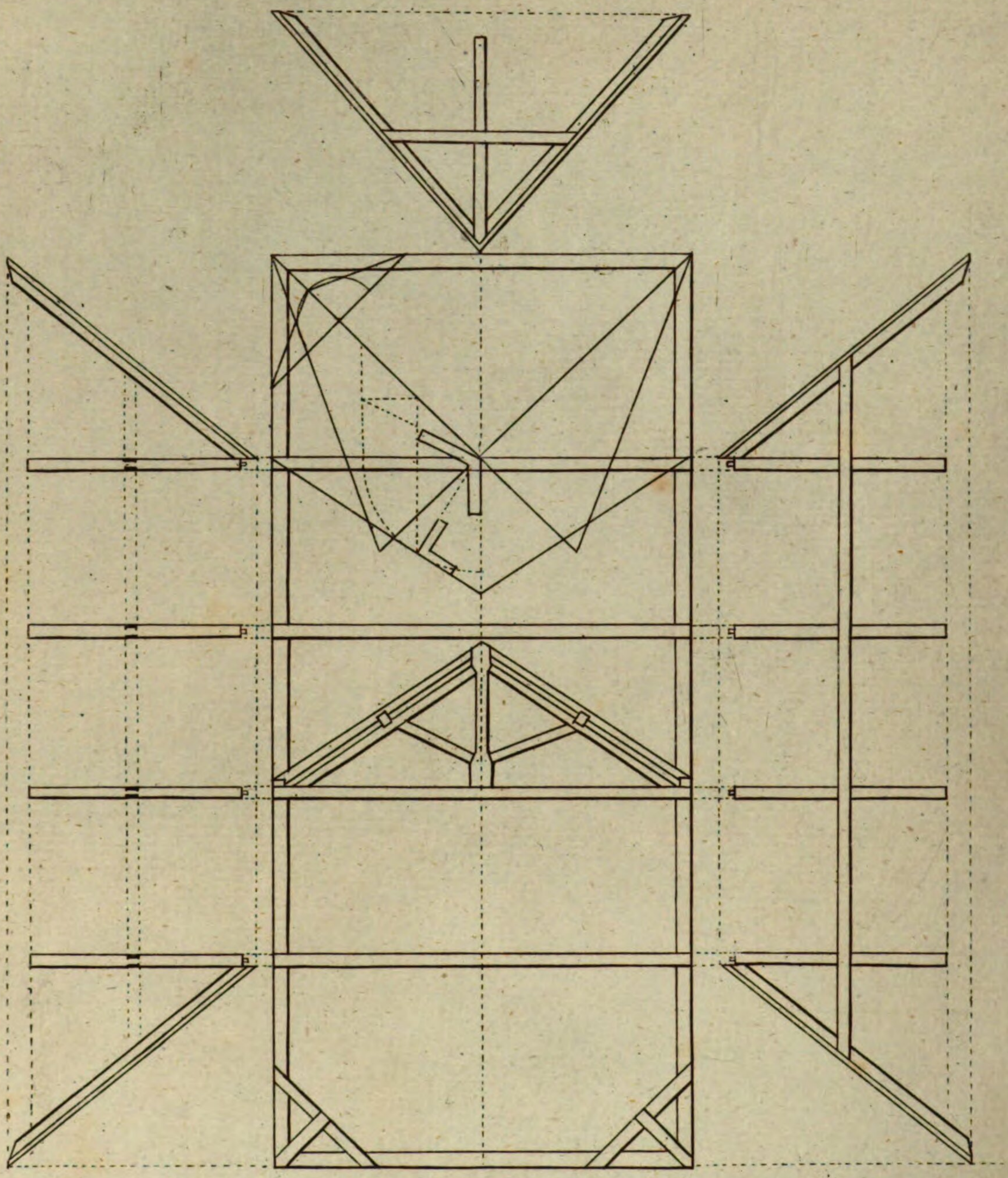

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Plate 34

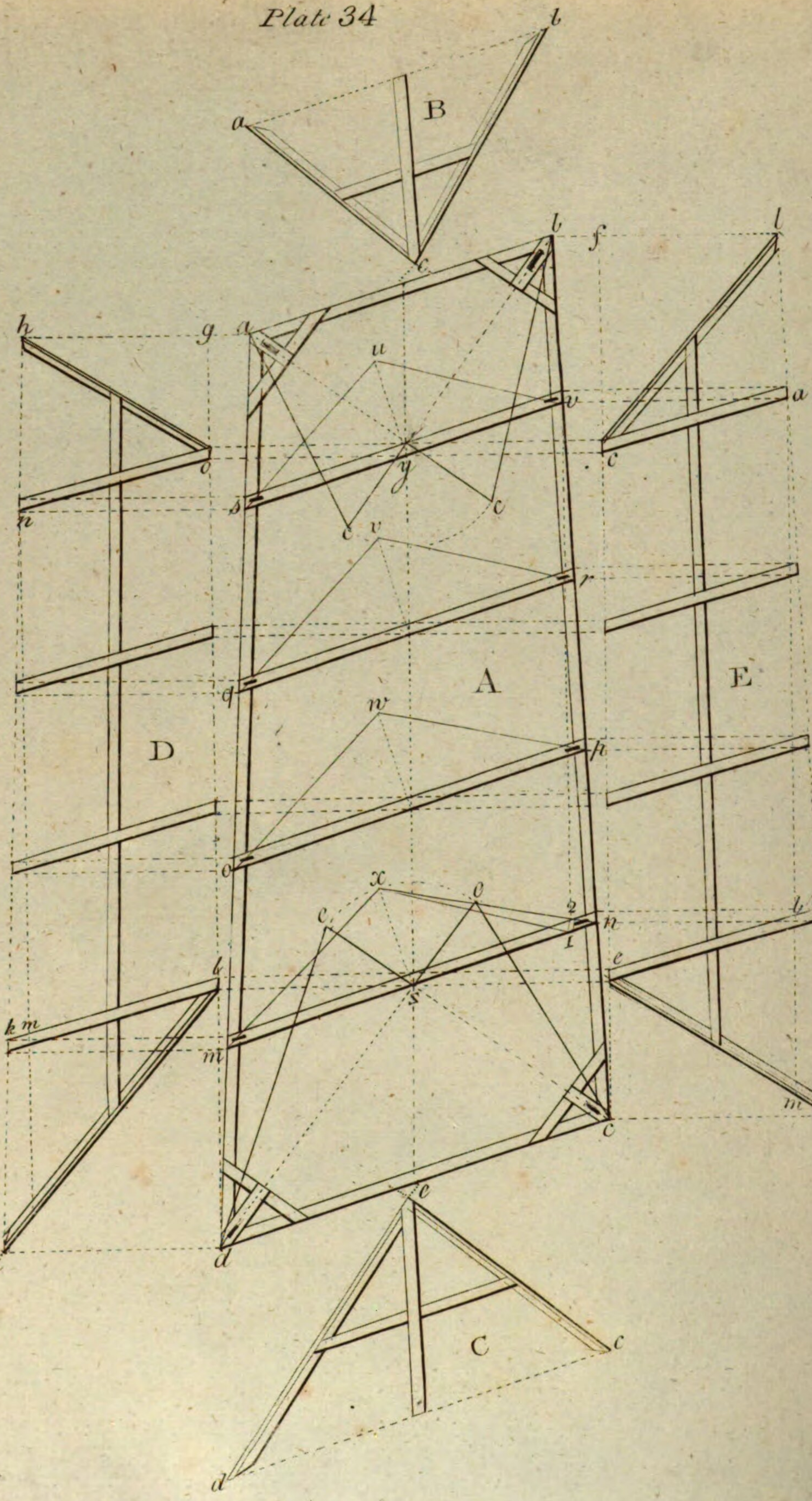

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PLATE XXXIII.

This plate ſhews the manner of framing a roof in ledgment; but as roofs are ſeldom executed in this manner, I ſhall not be very particular in deſcribing its lines. The following deſcription for winding will ſerve for any.

PLATE XXXIV.

How to lay out an irregular roof in ledgment, with all its beams lying bevel upon the plan, ſo that the ridge may be level when finiſhed; the plan and height of the room being given.

The lengths of the common and hip rafters are found as uſual. From each ſide in the broadeſt end of the roof, through *c* and *d*, draw two lines parallel to the ridge-line; draw lines from the centres and ends of the beams perpendicular to the ridge-line, and lay out the two ſides of the roof *D* and *E*, by making *e d* at *E* equal to *x n* in *A*, the length of the longeſt common rafter, and *c a* in *E* equal to *u v* at *A*, and ſo on with all the other rafters.

To find the winding of this roof.

Take *y v*, half the baſe of the ſhorteſt rafter; and apply this to the baſe of the longeſt rafter, from z to 1; then the diſtance from 1 to 2 ſhews the quantity of winding.

How to lay the ſides in winding.

Lay a ſtraight beam along the top ends of the rafters at *E*, that is, from *c* to *e*, and lay another beam along the line *a b*, parallel to it, to take the ends of the hip rafters at *m* and *l*, and the beams to be made out of winding at firſt. Raiſe the beam that lies from *a* to *b*, at the point *b*, to the diſtance 1 2 above the level; which beam, being thus raiſed, will raiſe all the ends of the rafters gradually, the ſame as they would be when in their places.

The ſame is to be underſtood of the other ſide *D*; the ends are laid down in the ſame manner as making a triangle of any three dimenſions.

To ſatisfy the curious, I have given the lines of this roof; but in practice there is not the leaſt occaſion for framing the ſides in winding, for inſtead of the ridge-line, the top is made level at the wideſt end of the roof, from the narroweſt end, which begins at a point; and by this means the ſides may be framed quite out of winding, which will have a much better effect than any winding roof can have.

PLATE XXXV.

POLYGON ROOFS.

The methods of conſtructing regular polygons upon any given ſide, are ſhewn at *fig.* 4, 5, and 6, in the Geometry.

The plan of a polygon roof being given, and one of the common ribs ſtanding upon that plan, to find the angle rib, and the form of the boards that will cover it when the ribs are fitted up.

In *fig. A* let *B* be the given rib; divide the curve into any number of equal parts, as four, and lay them at *D* from *a* to 4, which biſects *b b*, the ſide of the polygon, at right angles; through theſe points draw lines parallel to the ſide *b b* of the polygon; at *B* and *D* make 1 *c* at *D* equal to *c c*, between *B* and *C* 2 *d* equal to *d d*, and 3 *e* equal to *e e*, &c. and through the points *b*, *c*, *d*, *e*, *f*, draw a curve line, which will be the form of the boarding; from the points *g*, *f*, *e*, *d*, *c*, draw lines at right angles to *g b*, the baſe of the angle rib, and prick the rib *C* from *D* as they are marked by the letters, which is plain.

Note. The more parts there is in this operation, the truer it will be, or any other of this nature.

In the ſame manner may the covering and angle ribs of any other polygon be found, whatever may be the form of the ribs, as is ſhewn at figures *B* and *C*.

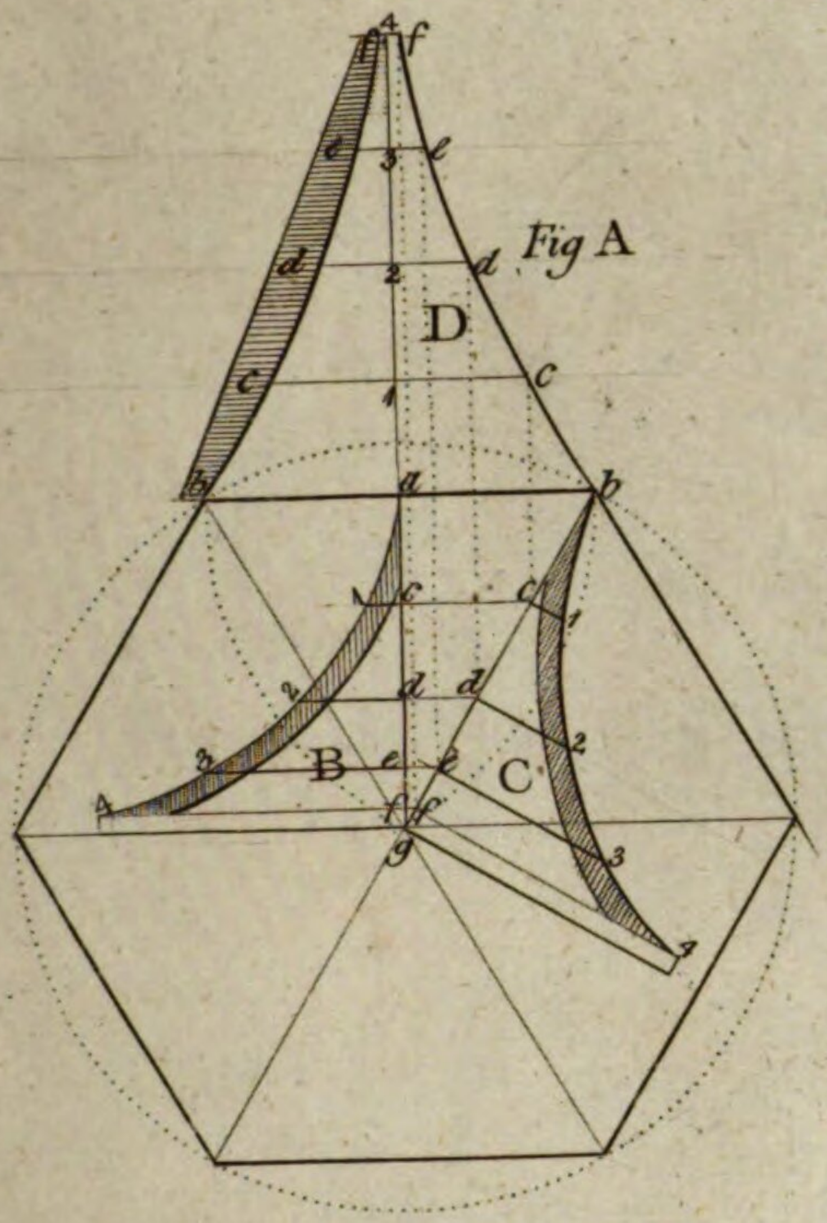
To find the covering of a ſpherical dome.

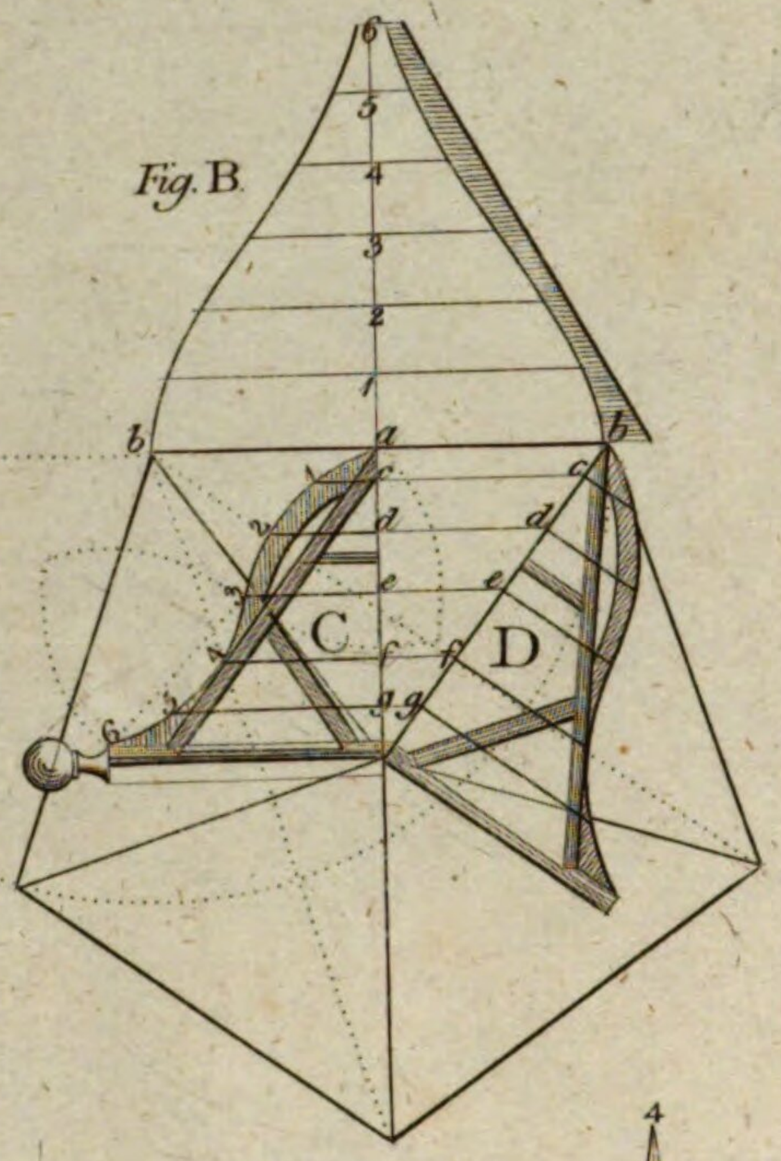
FIG. *D.* Make a circle *i c k f*, of the plan of the dome, and if it is a ſemi-globe take the ſtretch out of one quarter for the length of a board; make the length of *K* from *a* to 4 equal to it, and let the width *c c*, at the bottom, be any thing that the board will admit of; on the baſe *c c*, as a diameter, make a ſemicircle; divide half the arch-line into any number of equal parts; draw the little lines 1 1, 2 2, 3 3, parallel to *c c* the baſe of the board, and divide the height into the ſame number of equal parts; draw the ordinates acroſs; make 1 1, 2 2, 3 3, upon theſe ordinates, equal to 1 1, 2 2, 3 3, in the ſemicircle at the bottom; a curve being drawn through theſe points, will be the mould *K* for the covering.

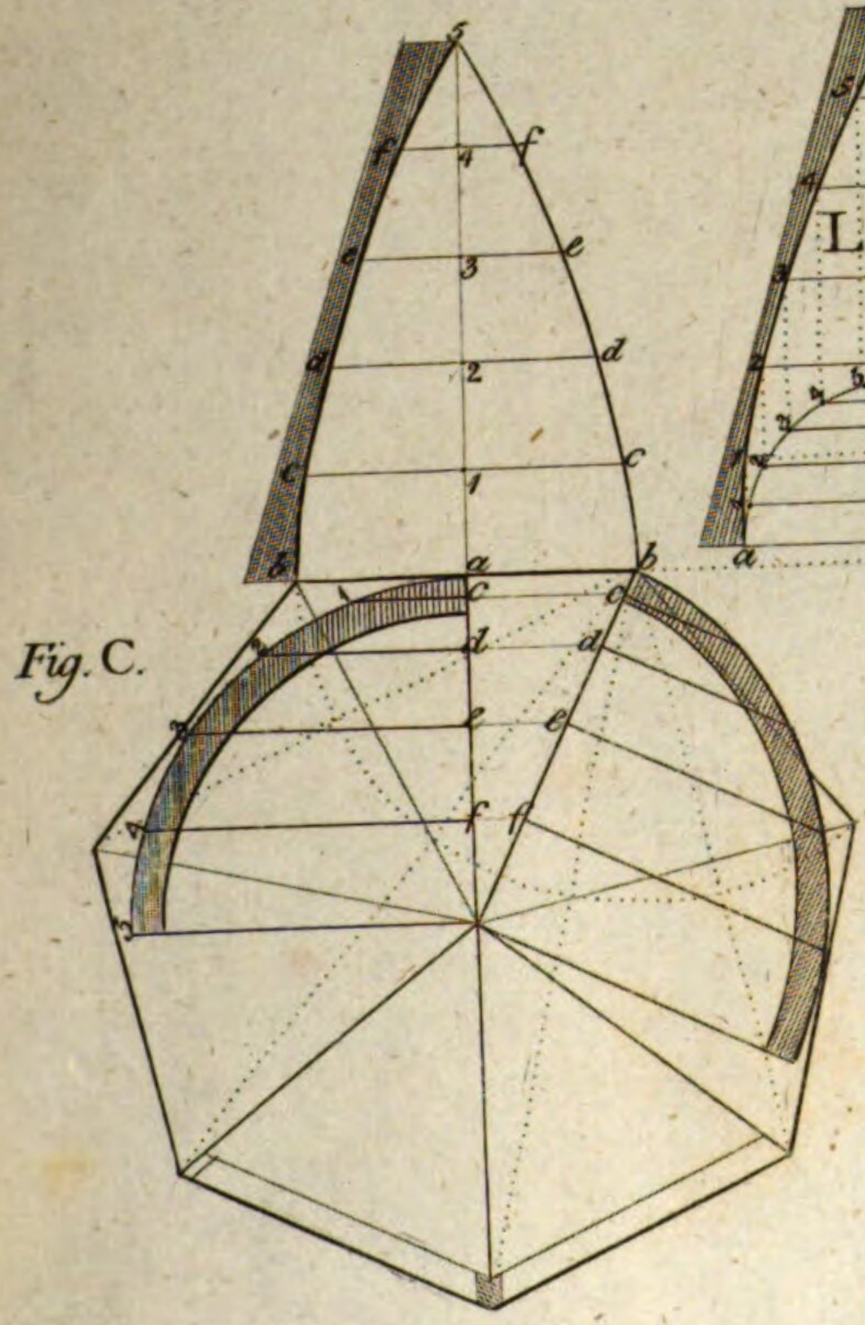
To cover a ſpherical dome when the top does not riſe ſo high as a ſemicircle, but only a ſegment.

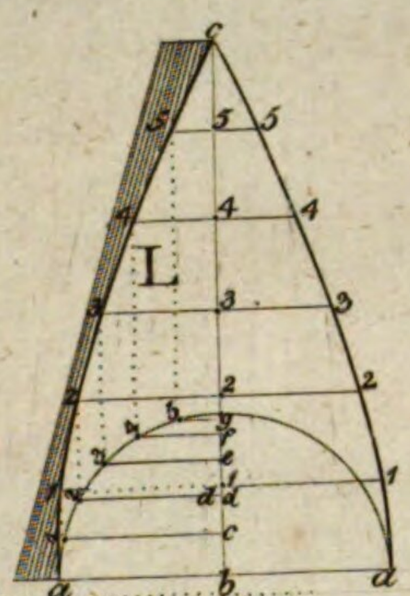
Suppoſe *l d* to be the height of the dome at *F*, and the width *c f* of the dome as before, upon the chord *c f*; with the perpendicular height *l d* deſcribe a ſegment, which will be the ſame as a vertical ſection ſtanding upon *c f*; here is only one half of the ſegment, which is ſufficient: draw the chord *c d*; take *c a* equal to half the width of a board, whatever it will admit of; draw *a b* perpendicular to cut the chord *c d* at *b*; take the ſtretch or circumference of the arch *c d*, and make the length of *I* from *a* to 4 equal to it; take the double of *a c*, at *F*, and make it the baſe of the board at *I*; take *a b* from *F*, and ſet it upon the baſe of *I*, upon the middle of *c c*, from *a* to *b*; and with the chord *c c*, and the height *a b*, deſcribe a ſegment upon the bottom of the board at *I*; divide one half into any number of equal parts; likewiſe divide the height of the board *I* into the ſame number of equal parts; draw ordinates in both, and the board *I* will be completed, as in the ſame manner is that of *H*, deſcribed before.

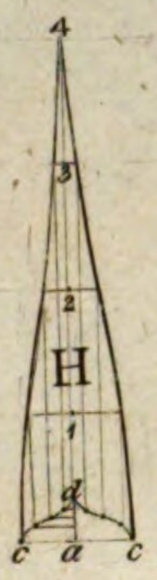
Plate 35.

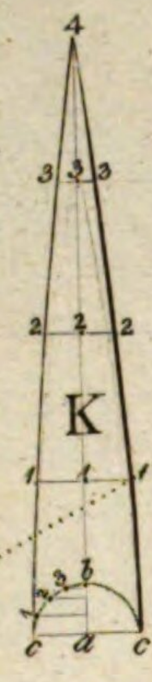












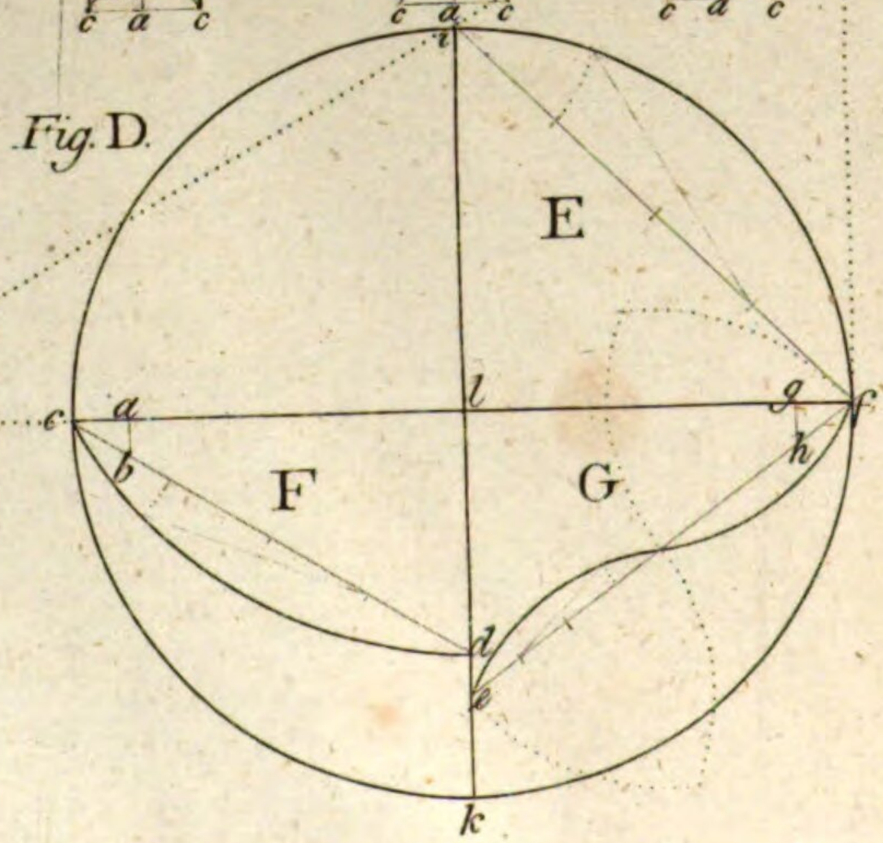
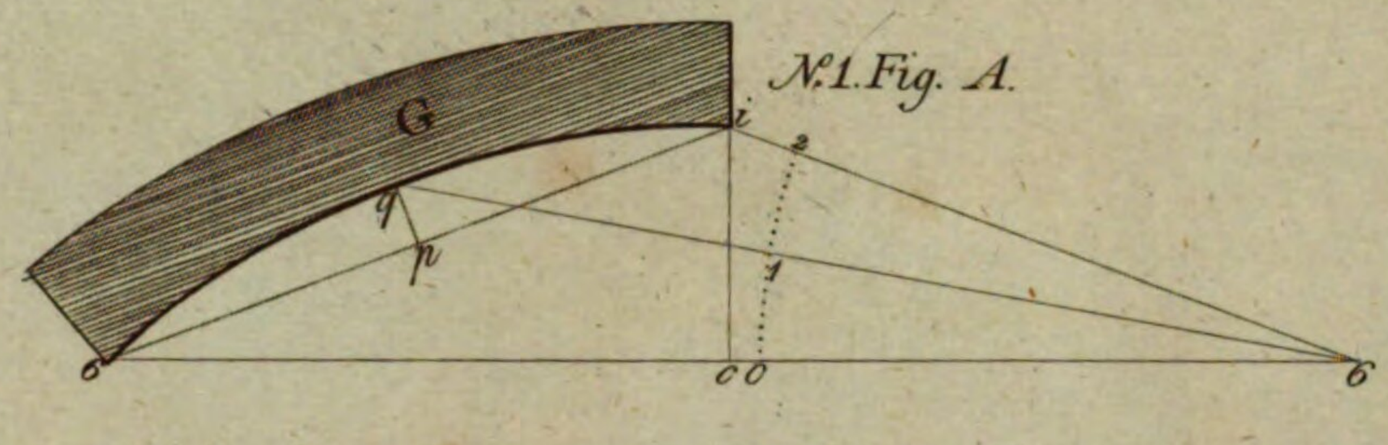
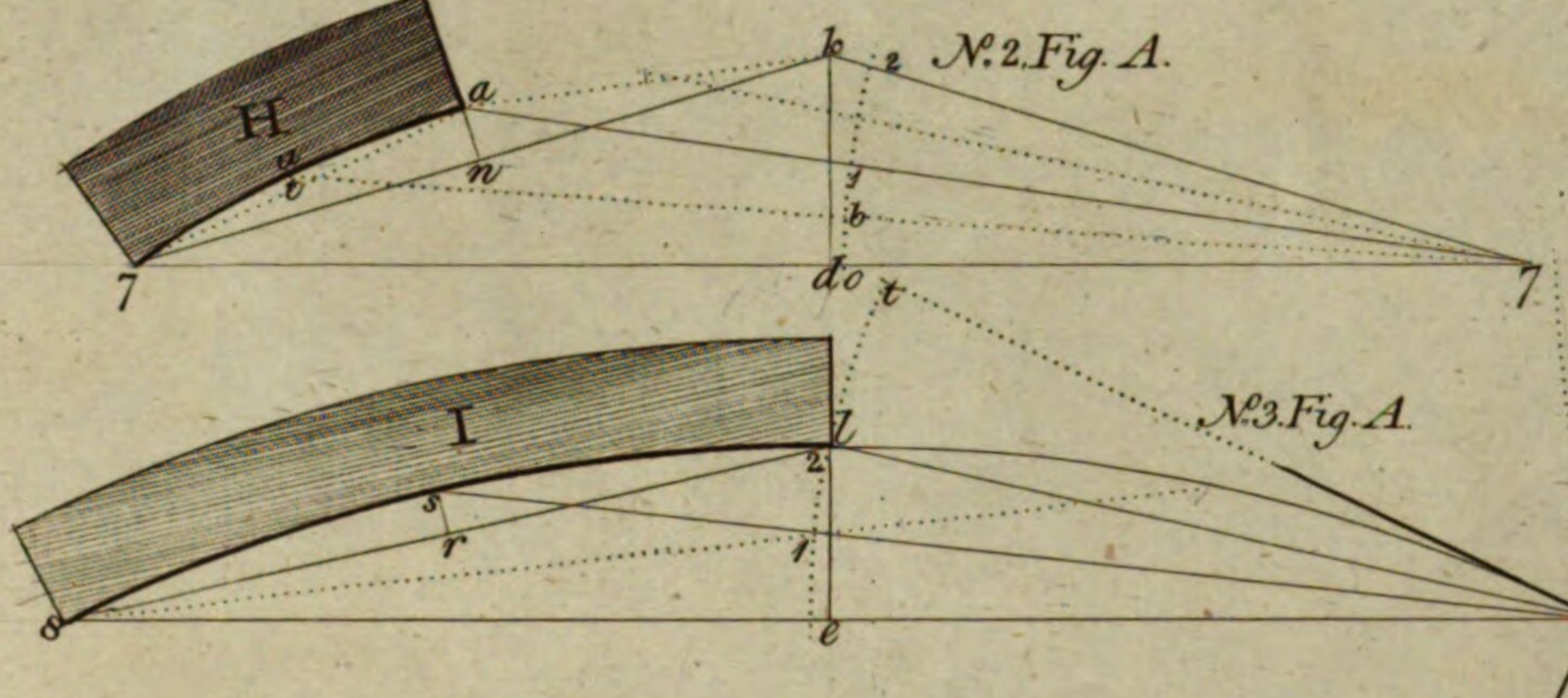


Plate. 36.





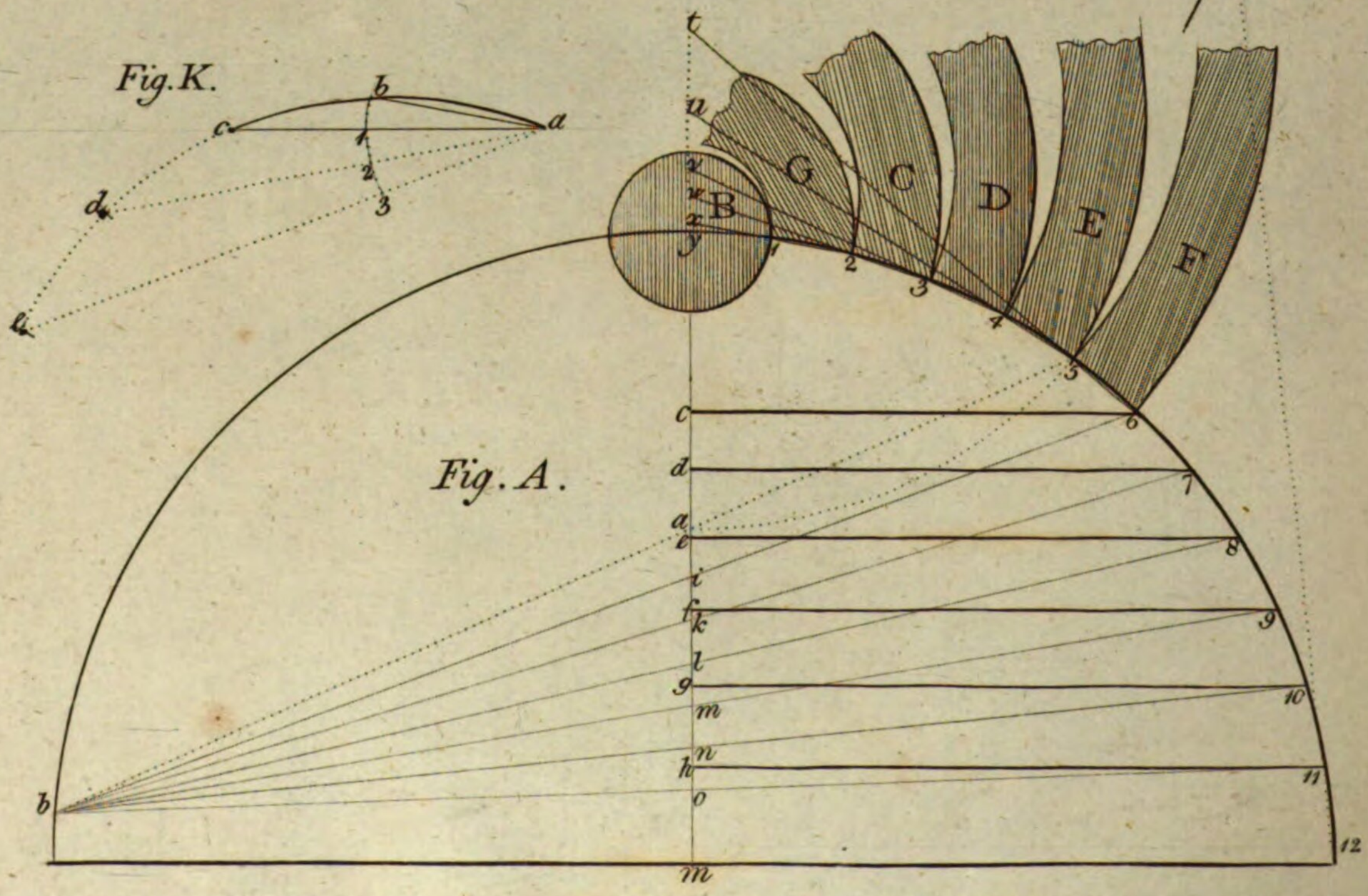


Fig. A.

PLATE XXXVI.

DOMES.

As the common method of finding the centres for deſcribing the boards to cover a horizontal dome will be found in practice very inconvenient, for thoſe boards which come near to the bottom; I ſhall in this place ſhew how to remedy that inconvenience.

To find the ſweep of the boards at the top. FIG. *A.*

Divide round the circumference of the dome into equal parts at 1, 2, 3, 4, 5, 6, &c. each diviſion to the width of a board, making proper allowance for the camber of each board; draw a line through the points 1, 2, to meet the axis of the dome at *x*; on *x*, as a centre, with the radii *x* 1 and *x* 2 deſcribe the two concentric circles, it will form the board *G*; in the ſame manner continue a line through the points 2 and 3 at *C*, to meet the axis in *w*; then *w* is the centre for the board *C*; proceed in the ſame manner for the boards *D*, *E*, and *F*.

Now ſuppoſe *F* to be the laſt board that you can conveniently find a centre, for want of room; on *t* its centre, and the radius *t* 5, make from *t* on the axis of the dome *t a*, equal to *t* 5; through the points 5 and *a* draw the dotted line 5 *b*, to cut the other ſide of the circumference of the dome at *b*; from the points 6, 7, 8, 9, 10, 11, draw radial lines to *b*, to cut the axis of the dome at *i*, *k*, *l*, *m*, *n*, *o*; alſo through the points 6, 7, 8, 9, 10, 11, draw the parallels 6 *c*, 7 *d*, 8 *e*, &c. then will each of theſe parallel lines be half the length of a chord-line for each board; then take *c* 6 from *fig. A*, which transfer to No. 1 from *c* to 6 and 6; make the height *c i*, at No. 1, equal to *c i*, at *fig. A*; and draw the chords *i* 6 and *i* 6; then upon either point 6, as a centre with any radius, deſcribe an arch of a circle o 1 2; divide it into two equal parts at 1, and through the points 6 and 1 draw 6 *q*; biſect *i* 6 in *p*; draw *p q* perpendicular; then *i* 6 is the length, and *p q* the height of the board *G*, which may be deſcribed as in *fig.* 4, plate 5, of the Geometry. The reader muſt obſerve, that the length of a board is of no conſequence ſo as the true ſweep is got, which is all that is required. Proceed in the ſame manner with No. 2, by taking *d y* from *fig. A*, and place it at No. 2, on each ſide of *d* at 7 and 7, and take *d k*, from *fig. A*, and make *d k* at No. 2, equal to it; draw the chords *k* 7 and *k* 7, and biſect *k* 7 at *n*; draw *n a* perpendicular; upon the other extremity at 7, as a centre, deſcribe an arch o 1 2, and biſect it at 1, and through the points 7 and 1 draw the line 7 *a*, to cut the perpendicular *n a* at *a*; but if the diſtance *k* 7 is too long for the length of a board, biſect the arch o 1 at *b*; through 7 and *b* draw 7 *t*, and draw the little chord *a* 7, and biſect it at *t*; draw *t u* perpendicular to interſect 7 4 at *u*; and with the chord 7 *a* and the height *t u*, deſcribe the ſegment *H*.

In the ſame manner may the next board *I* be found, and by this means you may bring the ſweep of your board into the ſmalleſt compaſs, without having any recourſe to the centre.

Suppoſe it were required to draw a tangent from 8 *at No.* 3, *without having recourſe to the centre.*

Biſect the arch 8 *l* 8 at *l* on 8, as a centre; with a radius 8 *l*, deſcribe an arch *e l t*; make *l t* equal to *l e*; draw the tangent *t* 8.

Given three points in the circumference of a circle, to find any number of equi-diſtant points beyond thoſe that will be in the ſame circumference.

FIG. *K.* Suppoſe the three points *a*, *b*, *c*, to be given to one of the extreme points *a*; join the other two points *b* and *c* by the lines *a b*, and *a c*; with a radius *a b*, and the centre *a*, deſcribe the arch of a circle *b* 1 2 3; then take *b* 1 and ſet it from 1 to 2, and from 2 to 3; through the points 2 and 3, draw *a d* and *a e*; then take *b c*, put the foot of your compaſs in *c*, and with the other foot croſs the line *a d* at *d*; with the ſame extent put the foot of your compaſs in *d*, and with the other foot croſs the line *a e* at *e*; in the ſame manner you may proceed for any number of points whatever.

PLATE XXXVII.

FIG. *A* is the plan of an elliptical dome; *B* is the longeſt ſection, *C* the ſhorteſt ſection; at *a a* in *B*, and *b b* in *C*, ſhews how to ſquare the purlines, ſo that one ſide may be fair with the ſurface of the dome; the dotted lines from *a a* in *B*, and *b b* in *C*, ſhews how to get the length and width of the purline in *fig. A*; but if the ſides of the purline were made to ſtand perpendicular over the plan, the ſweep of it would be found in the ſame manner as before; then it would require no more than half the ſtuff that the other would, and take only half the time in doing, which is a conſiderable advantage.

How to proportionate the inſide curb for the ſky-light, ſo as it ſhall anſwer to the ſurface of the dome.

Draw the diagonal *i l* and *k m* in *fig. A*, and let *h e* or *g f* be the width, then *h g* or *e f* will be the true length of the curb; becauſe every ſection parallel to the baſe will be proportional to the baſe of the dome.

To find the ribs for this dome.

The ribs in this are got in the ſame manner as the ribs for a niche, as directed in page 34; and if the reader uuderſtands that, he muſt know this.

To find the form of a board to ſtand in any place of this dome, to be bent up to the crown.

Suppoſe you would find a board over *a b c* in the plan; divide *D* into three parts round *a*, *b*, *c*, *d*, and draw *a c*, *b c*, *c c*, and *d c*, to the centre at *c*; then take the triangle *a b c* in *D*, and lay it down at *a b c* in *G*; then draw the line *c* 1 1 1, &c. at right angles to *a b*, and deſcribe a rib *G* to the height of the dome, and the length to the perpendicular of the triangle *a b c*, and divide it into five equal parts; lay them along the line 1 1 1, &c. in *H*, and prick the mould *H* from the triangle *a b c*, as the letters are marked. The board *K* will be found in the ſame manner.

Note. In the practice, you are to divide one quarter of this dome into as many parts as you think the breadth of a board will contain; and the boards, when got out by this method, will fit to a very great exactneſs; this is only into three, that the parts may be clearly ſeen to learners.

If the boards are got out for one quarter of this dome to the lines here laid down, the boards that are in the other three quarters will not require any other lines, for every board in the firſt quarter will be a mould for three more boards.

Plate 37.

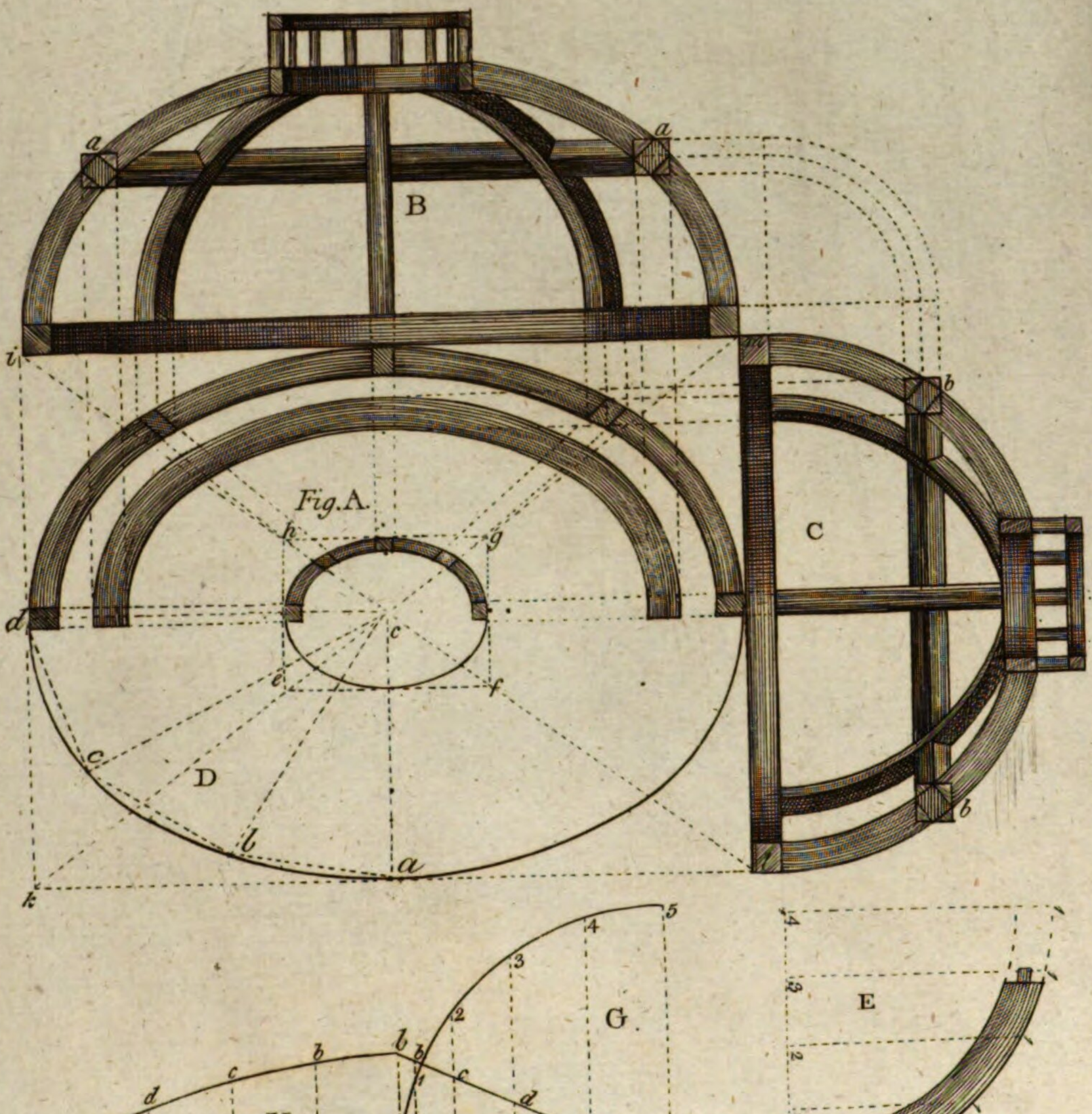


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Plate 38.

Fig. A.

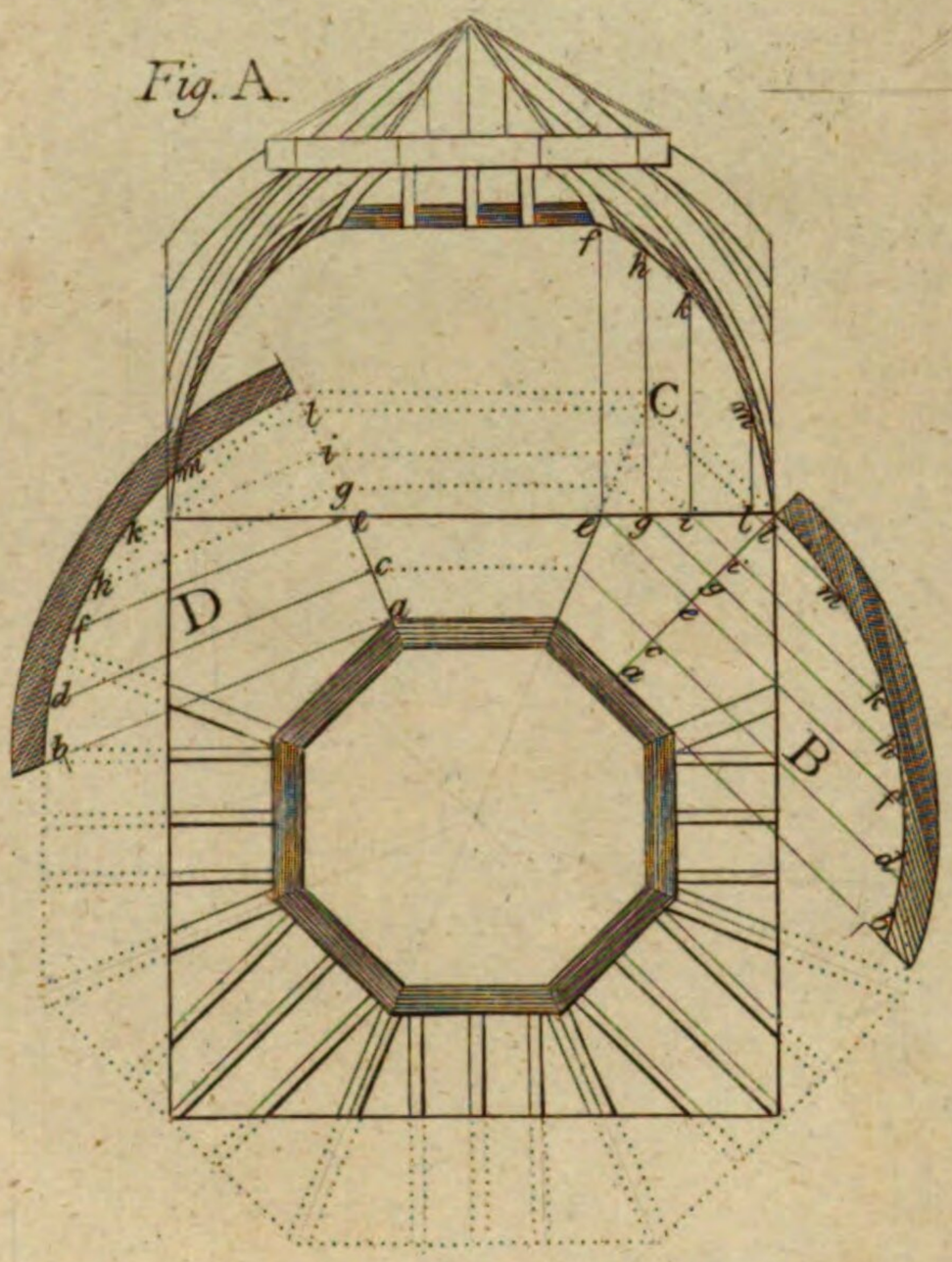


Fig. B.

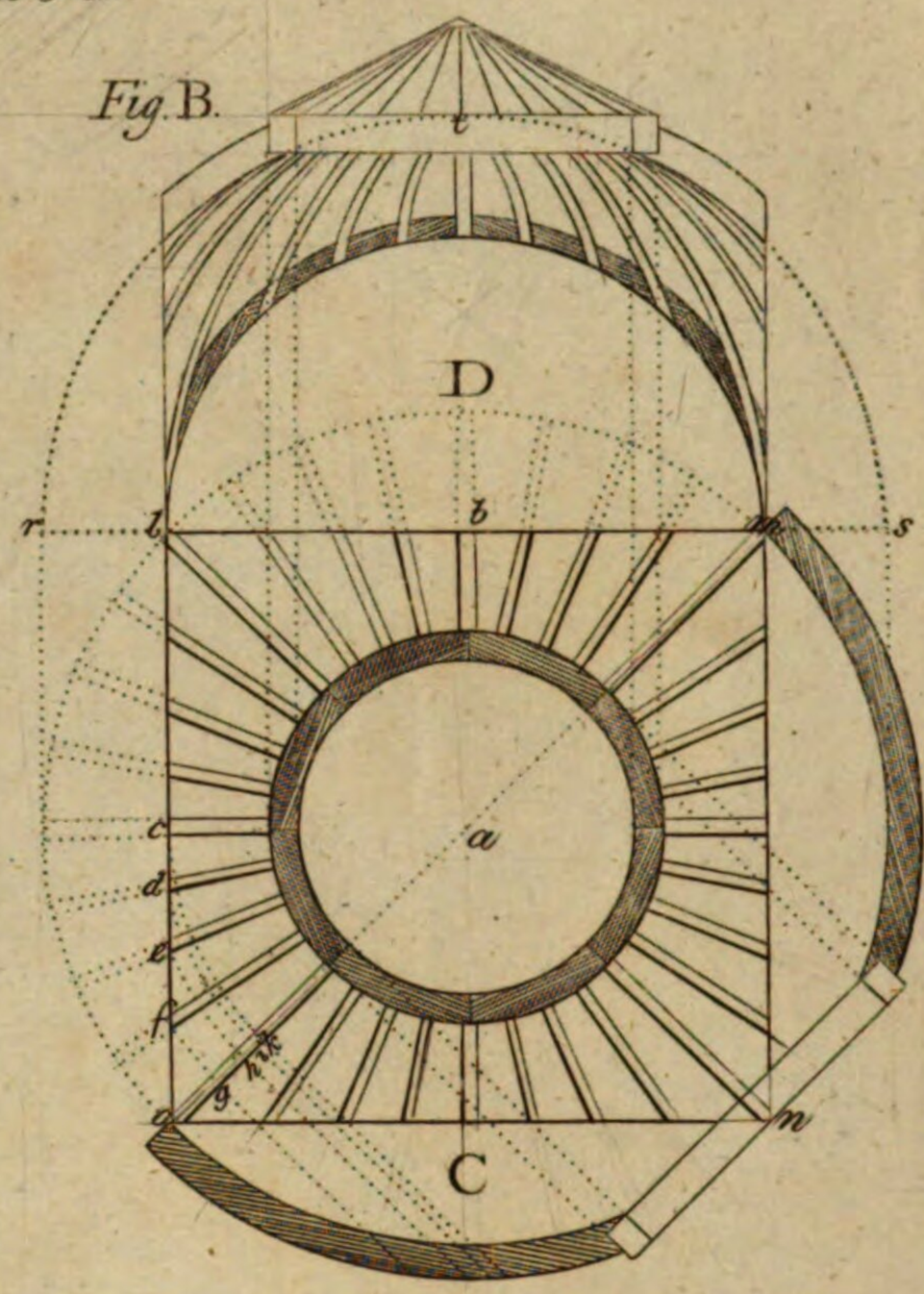


Fig. C.

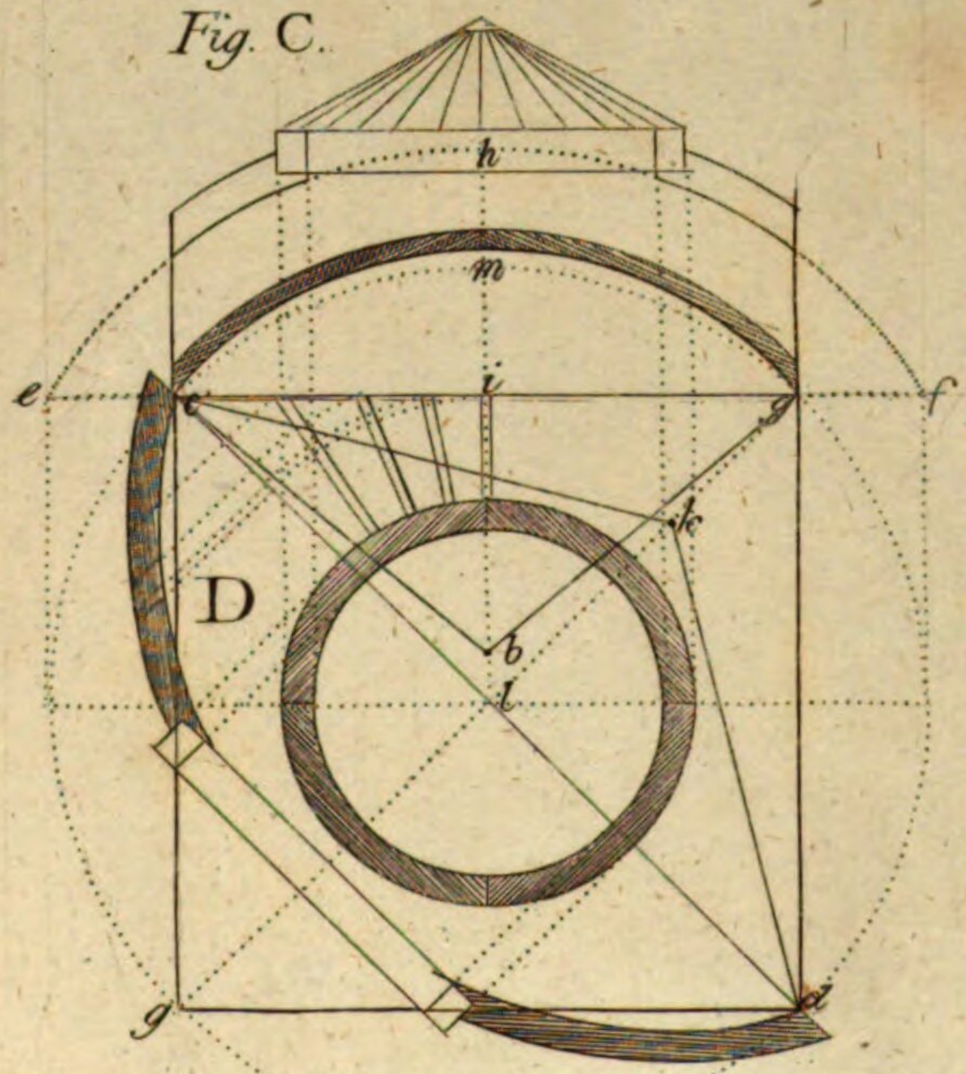


Fig. D.

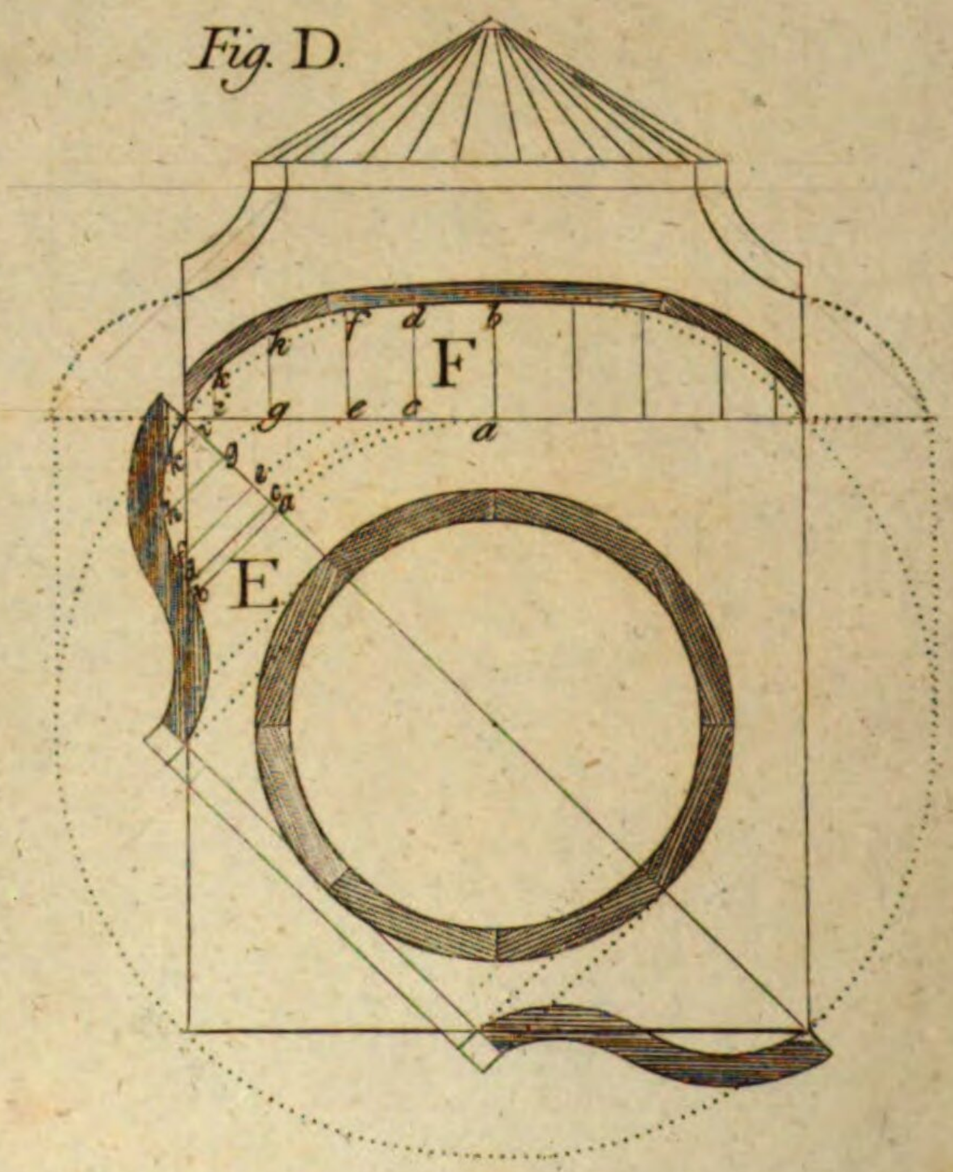


PLATE XXXVIII.

OF DOMES, WHEN PLACED OVER THE OPENINGS OF STAIR-CASES.

One of the ribs of a dome being given, and the plan of the opening of a ſtair-caſe which is ſquare, and an octagon curb at the top for a ſky-light; to find the ribs and the curve on each ſide of the opening of the ſtair-caſe, where the foot of the ribs comes, ſo that part of the dome ſhall be an octagon finiſh, agreeable to the curb.

FIG. *A.* Let *B* be the given rib; take any number of perpendicular ordinates to its baſe at pleaſure; from the points *a*, *c*, *e*, *g*, *i*, *l*, where they interſect its baſe, draw parallel lines to the ſides of the curb, returning round each diagonal, if there is more than one, till it cut the baſe of the angle rib *D*; at the points *a*, *c*, *e*, *g*, *i*, *l*, draw the ordinates of *D*, and prick it from *B*, will be the angle rib; and at the points *e*, *g*, *i*, *l*, at *C*, upon the ſide of the opening of the ſtair-caſe, draw the perpendicular ordinates and prick *C* from *B*, agreeable to the letters; then the curve *C* will be the true place for the foot of the ribs upon the ſide of the ſtair-caſe, and the part that lays in the middle is a ſtraight line parallel to the horizon.

The vertical ſection of a ſemicircular dome through its centre being given, the opening of the ſtair-caſe being a ſquare as before, to find the curve D *on the ſide of the ſtair-caſe for the foot of the ribs, ſo that it ſhall finiſh to a circular curb at the top.*

On the ſide of the ſtair-caſe *l m*, as a diameter, deſcribe a ſemicircle; *D* will be the true place for the foot of the ribs; this is evident, for every ſection of a ſemi-globe, at right angles to its baſe, is a ſemicircle, and this is the ſame thing if truly conſidered.

Note. All the ribs of this dome are cut by the rib at *C*, as explained by the perpendicular lines; draw round the centre *a*, from the points of each bracket, at *c d e f*, to the points *k i h g*; from theſe points draw perpendicular dotted lines, and theſe will ſhew what length each bracket muſt have according to its place.

The vertical ſection of a ſegment dome paſſing through its centre being given, the plan of the opening of the ſtair-caſe being ſtill a ſquare, as before, to find the ſection upon each ſide of the ſtair-caſe for the foot of the ribs, to finiſh to a circular curb at the top.

Let the ſection *D* acroſs the angle be given, whoſe centre is *k*, and the diſtance of the centre from the chord *k l*; biſect the ſide of the ſtair-caſe by the line *b h*, at right angles at the point *i*; from *i*, make *i b* equal to *l k*; with a radius *b g*, or *b c*, deſcribe the ſegment *c*; *m g* will be the true place of the foot of the ribs; all the other leſſer ribs are cut from the angle rib *D*; all this is evident from the ſections of a globe, which is already deſcribed in the Geometry.

FIG. *D* is of the ſame nature as the others, having an ogee top; the ſection *F* is traced from *E*.

PLATE XXXIX.

FIG. *A* is the plan of an elliptical domical ſky-light over a ſtair-caſe; *B* and *C* are the ſections, which ſhews how to place your ribs.

How to proportionate the length of the inſide curb to any width given.

Proceed as directed in page 40 for an elliptical dome, that will determine the true length to the width.

How to proportionate the circumſcribing ellipſis, to paſs through the angles at a, b, c, *and* d, *to have the ſame proportion as* a b, *and* b c, *the ſides of the ſtair-caſe.*

Proceed as directed in *fig.* 5, plate 6, in the Geometry.

To deſcribe the ribs.

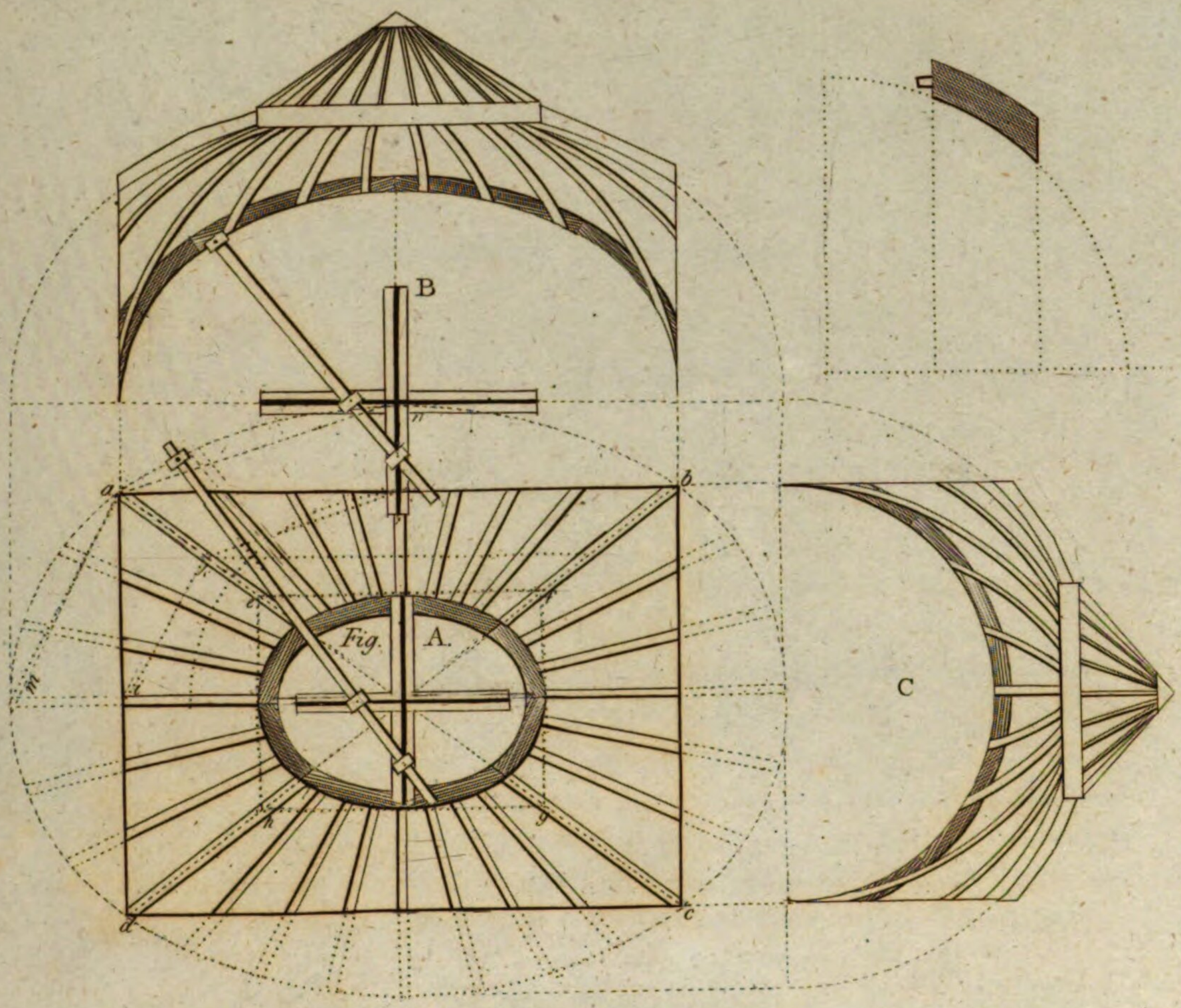
The rib over *n* to the centre of the trammel in *fig. A*, is a given quarter of a circle, as is ſhewn at *F*, and of courſe all the other ribs muſt come to the ſame height with it. Suppoſe it was required to find a rib over *d p*, you muſt take the full extent from *d* to the centre, and deſcribe the quarter of an ellipſis *D*; then the part over *d p* will be as much of it as is wanted: in the ſame manner *E* will be deſcribed, and the part over *i o* is what is wanted of this rib; the ſame letters are marked upon the baſes of *D* and *E*, as they are in the plan, *fig. A.* Every other rib is deſcribed in the ſame manner.

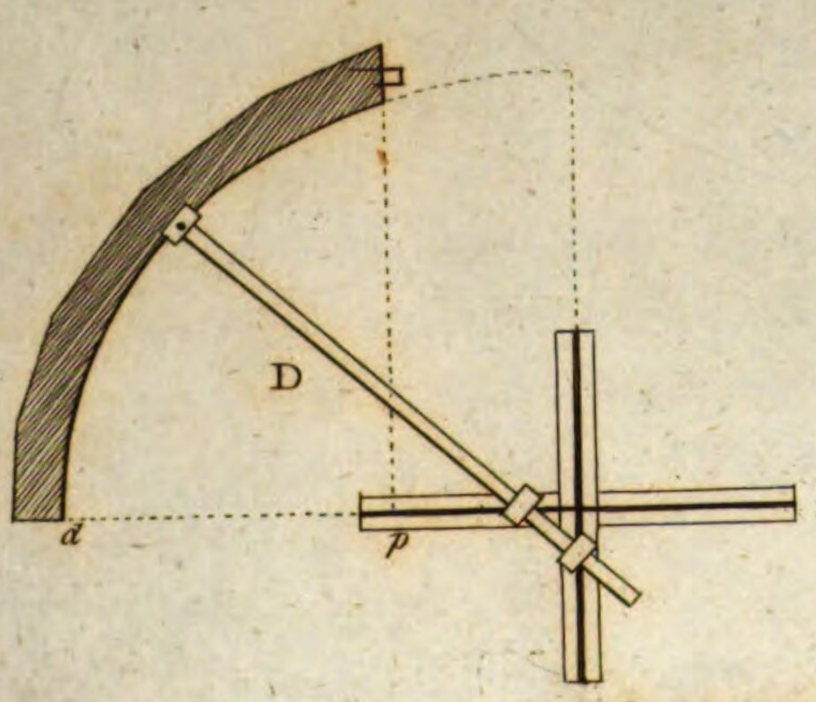
To find the ſections on each ſide of the ſtair-caſe for the foot of the ribs to ſtand upon.

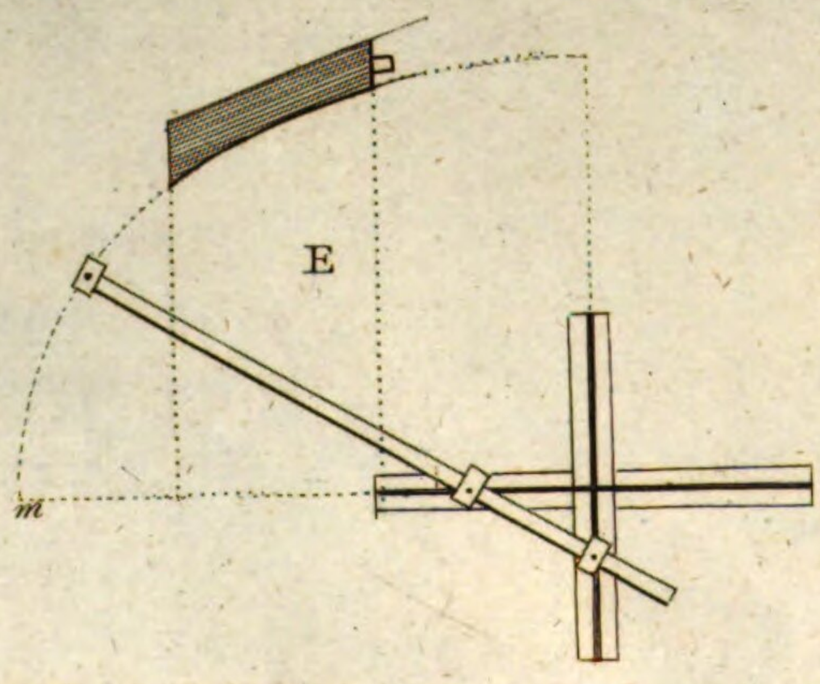
Deſcribe the ſemicircle *C*, to *c b*, the width of the opening of the ſtair-caſe, which will give the bottom of the ribs on that ſide; and deſcribe a quarter of the ellipſis *B*, for the bottom of the ribs on the other ſide, to the ſame height as *C.*

This method depends on this principle, that all the parallel ſections of a ſpheroid are ſimilar figures: therefore a vertical ſection ſtanding upon *a b*, will be ſimilar to a vertical ſection paſſing through its centre; both will be ſimilar ellipſes: but *a b* is an ordinate to the conjugate axis, and *b c* is an ordinate to the tranſverſe of the circumſcribing ellipſis; by conſtruction half the length of the parallelogram is to half the length of the ellipſis, as half the width of the parallelogram is to half the width of the ellipſis, and a ſpheroid may be ſuppoſed to be generated by the revolution of a ſemi-ellipſis about its axis; hence it follows, that all ſections of a ſpheroid parallel to the axis are ſimilar figures, conſequently the ſection *B* is ſimilar to the circumſcribing ellipſis of the ground plan.

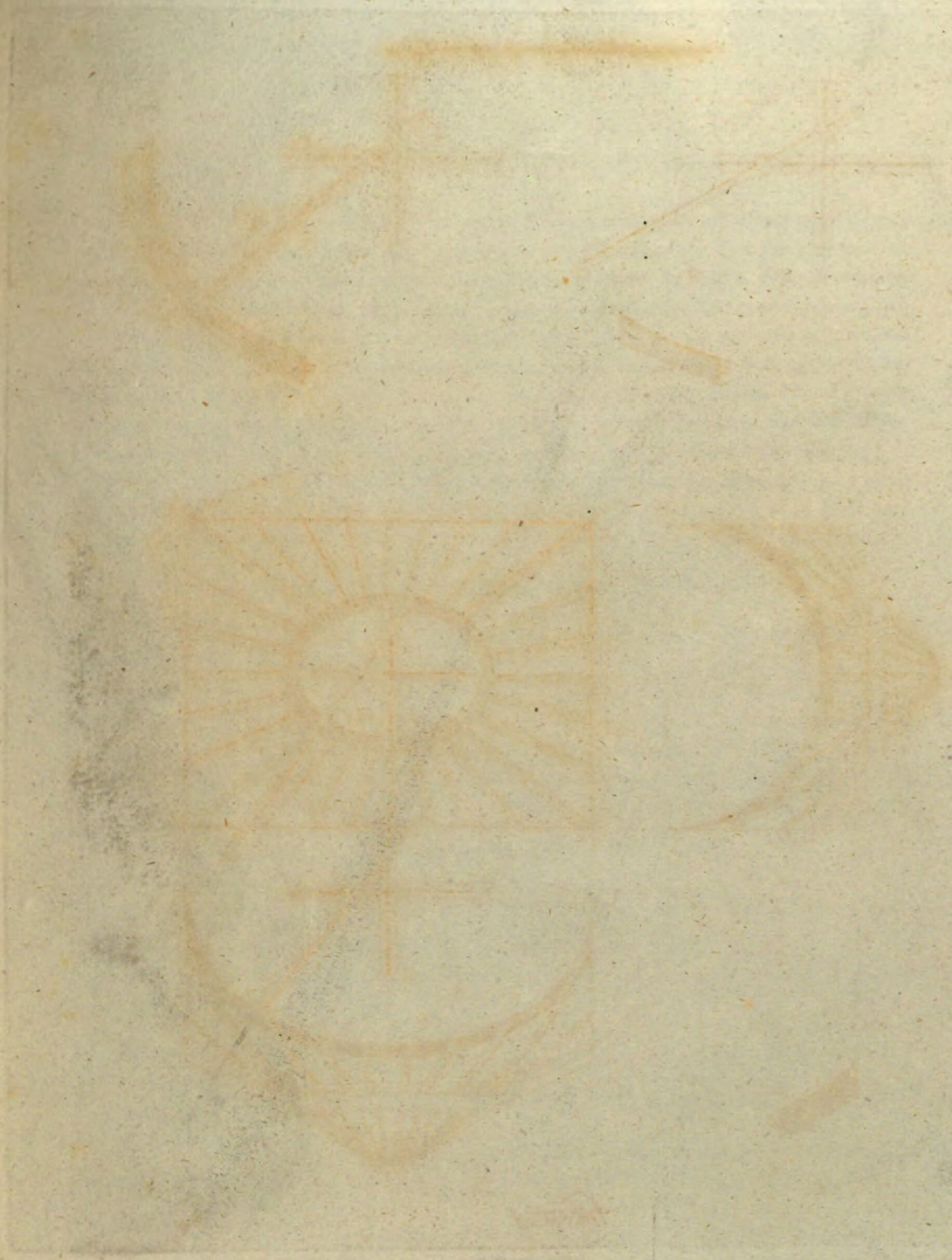
Plate 39.







Pub.d as the Act directs June 8. 1792 by P. Nicholson.



INTRODUCTION

TO

PRACTICAL CARPENTRY.

OF THE COMPARATIVE STRENGTH OF TIMBER.

PROPOSITION I.

THE ſtrengths of the different pieces of timber, each of the ſame length and thickneſs, are in proportion to the ſquare of the depth; but if the thickneſs is to be conſidered along with the depths, then the ſtrengths will be in proportion to the ſquare of the depth, multiplied into the thickneſs; and if all the three are taken jointly, then the weights that will break each will be in proportion to the ſquare of the depth, multiplied into the thickneſs, and divided by the length: this is proved by the doctrine of mechanics. Hence a true rule will appear, for proportioning the ſtrength of timbers to one another.

RULE.

Multiply the ſquare of the depth of each piece, into its thickneſs; and each product being divided by their reſpective lengths, will give the proportional ſtrength of each.

EXAMPLE.

Suppoſe three pieces of timber, of the following dimenſions:

The firſt, 6 inches deep, 3 inches thick, and 12 feet long.

The ſecond, 5 inches deep, 4 inches thick, and 8 feet long.

The third, 9 inches deep, 8 inches thick, and 15 feet long. The comparative weight that will break each piece is required.

OPERATIONS.

First.	Second.	Third.
6 deep	5 deep	9 deep
6	5	9
36	25	81
3 thick	4 thick	8 thick
Length 12)108	Length 8)100	Length 15)648(43 and a fifth.
9	12 and a half	60
		48
		45
		3

Therefore the weights that will break each are nearly in proportion to the numbers 9, 12, and 43, leaving out the fractions, in which you will obſerve, that the number 43 is almoſt 5 times the number 9; therefore the third piece of timber will almoſt bear 5 times as much weight as the firſt; and the ſecond piece nearly once and a third the weight of the firſt piece; becauſe the number 12 is once and a third greater than the number 9.

The timber is ſuppoſed to be every where of the ſame texture, otherwiſe theſe calculations cannot hold true.

PROPOSITION II.

Given the length, breadth, and depth of a piece of timber; to find the depth of another piece whoſe length and breadth are given, ſo that it ſhall bear the ſame weight as the firſt piece, or any number of times more.

RULE.

Multiply the ſquare of the depth of the firſt piece into its breadth, and divide that product by its length: multiply the quotient by the number of times as you would have the other piece to carry more weight than the firſt, and multiply that by the length of the laſt piece, and divide it by its width; out of this laſt quotient extract the ſquare root, which is the depth required.

EXAMPLE I.

Suppoſe a piece of timber 12 feet long, 6 inches deep, 4 inches thick; another piece 20 feet long, 5 inches thick; requireth its depth ſo that it ſhall bear twice the weight of the firſt piece.

6 deep

6 deep
6

36
4
---
12)144

12
2 times

24
20 length
---
5)480

96(9.7, or 9.8, nearly for the depth.
81
---
187)1500
1309

191

Proof.

9.7
9.7
---
67 9
873

94.09
1.91 remainder added

96.00
5
---
20)480

24

EXAMPLE II.

Suppoſe a piece of timber 14 feet long, 8 inches deep, 3 inches thick; requireth the depth of another piece 18 feet long, 4 inches thick, ſo that the laſt piece ſhall bear five times as much weight as the firſt.

8
8

64
3
---
half 7)192

27.4, &c.
5 times

137
9 half the length
---
4)1233

308.25(17.5 the depth nearly
1
---
27)208(
189
---
345).1925, &c.

As the length of both pieces of timber is diviſible by the number 2, therefore half the length of each is uſed inſtead of the whole; the anſwer will be the ſame.

PROPO-

PROPOSITION III.

Given the length, breadth, and depth of a piece of timber; to find the breadth of another piece whoſe length and depth is given, ſo that the laſt piece ſhall bear the ſame weight as the firſt piece, or any number of times more.

RULE.

Multiply the ſquare of the depth of the firſt piece into its thickneſs; that divided by its length, multiply the quotient by the number of times as you would have the laſt piece bear more than the firſt; that being multiplied by the length of the laſt piece, and divided by the ſquare of its depth, this laſt quotient will be the breadth required.

EXAMPLE I.

Given a piece of timber 12 feet long, 6 inches deep, 4 inches thick; and another piece 16 feet long, 8 inches deep; requireth the thickneſs, ſo that it ſhall bear twice as much weight as the firſt piece.

	Or this, at full length.
6	6 depth of the firſt piece
6	6
36	36
4	4 thickneſs of the firſt piece
3)144	Length 12)144
48	12
2	2 by the number of times ſtronger
96	24
4	16 length of the laſt piece
8)384	144
8) 48	24
6 thickneſs.	8)384
	8) 48
	6 thickneſs.

EXAMPLE

EXAMPLE II.

Given a piece of timber 12 feet long, 5 inches deep, 3 inches thick; and another piece 14 feet long, 6 inches deep; requireth the thickneſs, ſo that the laſt piece may bear four times as much weight as the firſt piece.

5
5

25
3
---
12)75

6.25
4

25.00
14

100
25
---
6)350
---
6) 58.266

9.788

PROPOSITION IV.

If the ſtreſs does not lay in the middle of the timber, but nearer to one end than the other, the ſtrength in the middle will be to the ſtrength in any other part of the timber, as 1 divided by the ſquare of half the length is to 1 divided by the rectangle of the two ſegments, which are parted by the weight.

EXAMPLE I.

Suppoſe a piece of timber 20 feet long, the depth and width is immaterial; ſuppoſe the ſtreſs or weight to lay five feet diſtant from one of its ends, conſequently from the other end 15 feet, then the above proportion will be $\frac{1}{10 \times 10} = \frac{1}{100} : \frac{1}{5 \times 15} = \frac{1}{75}$ as the ſtrength at 5 feet from the end is to the ſtrength at the middle, or 10 feet, or as $\frac{100}{100} = 1 : \frac{100}{75} = 1\frac{1}{3}$.

Hence it appears, that a piece of timber 20 feet long is one third ſtronger at 5 feet diſtance from the bearing, than it is in the middle, which is 10 feet, when cut in the above proportion.

EXAMPLE

EXAMPLE II.

Suppoſe a piece of timber 30 feet long; let the weight be applied 4 feet diſtant from one end, or more properly from the place where it takes its bearing, then from the other end it will be 26 feet, and the middle is 15 feet; then $\frac{1}{15\times15} = \frac{1}{225} : \frac{1}{4\times26} = \frac{1}{104}$ or as $\frac{225}{225}$ $= 1 : \frac{225}{104} = 2\ \frac{17}{104}$ or nearly $2\frac{1}{6}$.

Hence it appears, that a piece of timber 30 feet long will bear double the weight, and one ſixth more, at 4 feet diſtant from one end, than it will do in the middle, which is 15 feet diſtant.

EXAMPLE III.

Allowing that 266 pounds will break a beam 26 inches long, requireth the weight that will break the ſame beam when it lays at 5 inches from either end; then the diſtance to the other end is 21 inches; $21 \times 5 = 105$, the half of 26 inches is 13 $\therefore$ $13 \times 13 = 169$; therefore the ſtrength at the middle of the piece is to the ſtrength at 5 inches from the end, as $\frac{169}{169} :: \frac{169}{105}$ or as $1 : \frac{169}{105}$ the proportion is ſtated thus:

lb.

$1 : \frac{169}{105} :: 266$: to the weight required,

169

2394

1596

266

105)44954(428

420

295

270

854

840

14

From this calculation it appears, that rather more than 428 pounds will break the beam at 5 inches diſtant from one of its ends, if 266 pounds will break the ſame beam in the middle.

By ſimilar propoſitions the ſcantlings of any timber may be computed, ſo that they ſhall ſuſtain any given weight; for if the weight one piece will ſuſtain be known, with its

its dimenſions, the weight that another piece will ſuſtain, of any given dimenſions, may alſo be computed. The reader muſt obſerve, that although the foregoing rules are mathematically true, yet it is impoſſible to account for knots, croſs-grained wood, &c. ſuch pieces being not ſo ſtrong as thoſe which are ſtraight in the grain; and if care is not taken in chooſing the timber for a building, ſo that the grain of the timbers runs nearly equal to one another, all rules which can be laid down will be baffled, and conſequently all rules for juſt proportion will be uſeleſs in reſpect to its ſtrength. It will be impoſſible, however, to eſtimate the ſtrength of timber fit for any building, or to have any true knowledge of its proportions, without ſome rule; as without a rule every thing muſt be done by mere conjecture.

Timber is much weakened by its own weight, except it ſtand perpendicular, which will be ſhewn in the following problems; if a mortice is to be cut in the ſide of a piece of timber, it will be much leſs weakened when cut near the top, than it will be if cut at the bottom, provided the tenent is drove hard in to fill up the mortice.

The bending of timber will be nearly in proportion to the weight that is laid on it; no beam ought to be truſted for any long time with above one third or one fourth part of the weight it will abſolutely carry; for experiment proves, that a far leſs weight will break a piece of timber when hung to it for any conſiderable time, than what is ſufficient to break it when firſt applied.

PROBLEM I.

Having the length and weight of a beam that can juſt ſupport a given weight, to find the length of another beam of the ſame ſcantling, that ſhall juſt break with its own weight:

Let l = the length of the firſt beam,
L = the length of the ſecond;
a = the weight of the firſt beam,
w = the additional weight that will break it.

And becauſe the weights that will break beams of the ſame ſcantling are reciprocally as their lengths,

therefore $\frac{1}{l} : \frac{1}{L} :: w + \frac{a}{2} : \frac{\sqrt{w + \frac{a}{2} \times l}}{L} = W$ = the weight that will break the greater beam;

becauſe $w + \frac{a}{2}$ is the whole weight that will break the leſſer beam.

But the weights of beams of the ſame ſcantling are to one another as their lengths:

Whence, $l : L :: \frac{a}{2} : \frac{L\,a}{2\,l} = W$ half the weight of the greater beam.

Now the beam cannot break by its own weight, unleſs the weight of the beam be equal to the weight that will break it:

Wherefore, $\frac{L\,a}{2\,l} = \frac{\sqrt{w + \frac{a}{2} \times l}}{L} = \frac{\sqrt{2w + a} \times l}{2L}$

$L^2 a = 2\sqrt{w + a} \times l^2$

$\therefore a : 2w + a :: l^2 : L^2$, conſequently $\sqrt{L^2} = L$ = the length of the beam that can juſt ſuſtain its own weight.

PROBLEM II.

Having the weight of a beam that can juſt ſupport a given weight in the middle; to find the depth of another beam ſimilar to the former, ſo that it ſhall juſt ſupport its own weight.

Let d = the depth of the firſt beam;
x = the depth of the ſecond beam;
a = the weight of the firſt beam;
w = the additional weight that will break the firſt beam:

then will $w + \frac{a}{2}$ or $\frac{2w+a}{2}$ = the whole weight that will break the leſſer beam.

And becauſe the weights that will break ſimilar beams, are as the ſquares of their lengths,

$$\therefore d^2 : x^2 :: \frac{2w+a}{2} : \frac{2x^2w+x^2a}{2d^2} = W$$

the weights of ſimilar beams are as the cubes of their correſponding ſides:

$$\text{Hence } d^3 : x^3 :: \frac{a}{2} : \frac{ax^3}{2d^3} = W$$

$$\therefore \frac{ax^3}{2d^3} = \frac{2x^2w+x^2a}{2d^2}$$

$$ax = \overline{2w+a} \times d$$

$$\therefore a : a+2w :: d : x = \text{the depth required.}$$

As the weight of the leſſer beam is to the weight of the leſſer beam, together with the additional weight; ſo is the depth of the leſſer beam, to the depth of the greater beam.

Note. Any other correſponding ſides will anſwer the ſame purpoſe, for they are all proportional to one another.

EXAMPLE.

Suppoſe a beam whoſe weight is one pound, and its length 10 feet, to carry a weight of 399.5 pounds, requireth the length of a beam ſimilar to the former, of the ſame matter, ſo that it ſhall break with its own weight:

then $a = 1$
and $a + 2w = 800$
$d = 10$

Then by the laſt problem it will be

$$1 : 800 :: 10$$
$$10$$
$$\overline{8000} = x \text{ for the length of a beam that will break by its own weight.}$$

PROBLEM

PROBLEM III.

The weight and length of a piece of timber being given, and the additional weight that will break it, to find the length of a piece of timber ſimilar to the former, ſo that this laſt piece of timber ſhall be the ſtrongeſt poſſible:

Put l = the length of the piece given,
w = half its weight,
W = the weight that will break it;
x = the length required.

then, becauſe the weights that will break ſimilar pieces of timber are in proportion to the ſquares of their lengths,

$\therefore l^2 : x^2 :: W + w : \frac{W x^2 + w x^2}{l^2}$ = the whole weight that breaks the beam;

and becauſe that the weights of ſimilar beams are as the cubes of their lengths, or any other correſponding ſides,

then $l^3 : x^3 :: w : \frac{w x^3}{l^3}$ the weight of the beam;

conſequently $\frac{W x^2 + w x^2}{l^2} - \frac{w x^3}{l^3}$ is the weight that breaks the beam = a maximum; therefore its fluxion is nothing,

that is, $2 W x \dot{x} + 2 w x \dot{x} - \frac{3 w x^2 \dot{x}}{l}$ = nothing.

$$2 W + 2 w = \frac{3 w x}{l}$$

hence, $x = l \times \frac{2 W + 2 w}{3 w}$

Hence it appears from the foregoing problems, that large timber is weakened in a much greater proportion than ſmall timber, even in ſimilar pieces, therefore a proper allowance muſt be made for the weight of the pieces, as I ſhall here ſhew by an example.

Suppoſe a beam 12 feet long, and a foot ſquare, whoſe weight is 3 hundred weight, to be capable of ſupporting 20 hundred weight, what weight will a beam 20 feet long, 15 inches deep, and 12 thick, be able to ſupport?

12 inches ſquare	15
12	15
144	75
12	15
12)1728	225
144	12
	2.0)270.0
	135

But the weight of both beams are as their ſolid contents;

therefore, 12 inches ſquare — 15 deep
12 — 12 wide

144 — 180
144 inches = 12 feet long — 240 length in inches

576 — 7200
576 — 360
144

20736 ſolid contents of the 1ſt beam. — 43200 ſolid contents of the 2d beam.

20736 : 43200 :: 3 — 144 :: 135 :: 21.5 by prop. 1.
3 — 21.5
cwt. lb.

20736) 129600(6.. — 28 = the weight of the 2d beam — 67 5
124416 — 135
270

..5184 — 12)2902.5
112

10368 — 12) 241.875
5184
5184

20736)580608(28 — 20.15625
41472 — 112

165888 — 31250
165888 — 15625
15625

..... — 17,50000
16

30
5

8,0

21 cwt. 56 lb. is the weight that will break the firſt beam, and 20 cwt. 17 lb. 8 oz. the weight that will break the ſecond beam; deduct out of theſe half their own weight.

20..17..8
3..14..0 half

17...3..8

Now 20 cwt. is the additional weight that will break the firſt beam; and 17 cwt. 3 lb. 8 oz. the weight that will break the ſecond: In which the Reader will obſerve, that 17..3..8 has a much leſs proportion to 20, than 20 cwt. 17 lb. 8 oz. has to 21..56. From theſe examples the Reader may ſee that a proper allowance ought to be made for all horizontal beams; that is, half the weights of beams ought to be deducted out of the whole weight that they will carry, and that will give the weight that each piece will bear.

If ſeveral pieces of timber of the ſame ſcantling and length are applied one above another, and ſupported by props at each end, they will be no ſtronger than if they were laid ſide by ſide; or this, which is the ſame thing, the pieces that are applied one above another are no ſtronger than one ſingle piece whoſe width is the width of the ſeveral pieces collected into one, and its depth the depth of one of the pieces; it is therefore uſeleſs to cut a piece of timber lengthways, and apply the pieces ſo cut one above another, for theſe pieces are not ſo ſtrong as before, even if bolted.

EXAMPLE.

Suppoſe a girder 16 inches deep, 12 inches thick, the length is immaterial, and let the depth be cut lengthways in two equal pieces; then will each piece be 8 inches deep, and 12 inches thick. Now, according to the rule of proportioning timber, the ſquare of 16 inches, that is, the depth before it was cut, is 256, and the ſquare of 8 inches is 64; but twice 64 is only 128, therefore it appears that the two pieces applied one above another is but half the ſtrength of the ſolid piece, becauſe 256 is double 128.

If a girder be cut lengthways in a perpendicular direction, the ends turned contrary, and then bolted together, it will be but very little ſtronger than before it was cut; for although the ends being turned give to the girder an equal ſtrength throughout, yet wherever a bolt is, there the girder will be weaker, and I am very doubtful whether it will be any ſtronger for this proceſs of ſawing and bolting; and I ſay this from experience.

If there are two pieces of timber of an equal ſcantling (Pl. 52, *fig. B*), the one lying horizontal and the other inclined, the horizontal piece being ſupported at the points *e* and *f*, and the inclined piece at *c* and *d*, perpendicularly over *e* and *f*, according to the principles of mechanics, theſe pieces will be equally ſtrong. But, to reaſon a little on this matter, let it be conſidered that although the inclined piece *D* is longer, yet the weight has leſs effect upon it when placed in the middle, than the weight at *h* has upon the horizontal piece *C*, the weights being the ſame; it is therefore reaſonable to conclude, that in theſe poſitions the one will bear equal to the other.

The foregoing rules will be found of excellent uſe when timber is wanted to ſupport a great weight; for, by knowing the ſuperincumbent weight, the ſtrength may be computed to a great degree of exactneſs, ſo that it ſhall be able to ſupport the weight required. The conſequence is as bad when there is too much timber, as when there is too little, for nothing is more requiſite than a juſt proportion throughout the whole building, ſo that the ſtrength of every part ſhall always be in proportion to the ſtreſs; for when there is more ſtrength given to ſome pieces than others, it encumbers the building, and conſequently the foundations are leſs capable of ſupporting the ſuperſtructure.

No judicious perſon, who has the care of conducting buildings, ſhould rely on tables of ſcantlings, ſuch as are commonly in books; for example, in ſtory poſts the ſcantlings, according to ſeveral authors, are as follows:

For	9	feet high	6 inches ſquare
	12	——	8
	15	——	10
	18	——	12

Now,

Now, according to this table, the ſcantlings are increaſed in proportion to the height; but there is no propriety in this, for each of theſe will bear weight in proportion to the numbers 9, 16, 25, and 36, that is, in proportion to the ſquare of their heights, 36 being 4 times 9; therefore the piece that is 18 feet long, will bear four times as much weight as that piece which is 9 feet long; but the 9 feet piece may have a much greater weight to carry than an eighteen feet piece, ſuppoſe double, in this caſe it muſt be near 12 inches ſquare inſtead of 6. The ſame is alſo to be obſerved in breaſt-ſummers, and in floors where they are wanted to ſupport a great weight; but in common buildings, where there is only cuſtomary weights to ſupport, the common tables for floors will be near enough for practice.

To conclude the ſubject, it may be proper to notice the following obſervations which ſeveral authors have judiciouſly made, viz. that in all timber there is moiſture, wherefore all bearing timber ought to have a moderate camber or roundneſs on the upper ſide, for till that moiſture is dried out the timber will ſwag with its own weight.

But then obſerve, that it is beſt to truſs girders when they are freſh ſawn out, for by their drying and ſhrinking, the truſſes become more and more tight.

That all beams or ties be cut, or in framing forced to a roundneſs ſuch as an inch in twenty feet length, and that principal rafters alſo be cut or forced in framing, as before; becauſe all joiſts, though ever ſo well framed, by the ſhrinking of the timber and weight of the covering will ſwag, ſometimes ſo much as not only to be viſible, but to offend the eye; by this precaution the truſs will always appear well.

Likewiſe obſerve, that all caſe bays either in floors or roofs do not exceed twelve feet if poſſible, that is, do not let your joiſts in floors exceed twelve feet, nor your purlines in roofs, &c. but rather let their bearing be eight, nine, or ten feet; this ſhould be regarded in forming the plan.

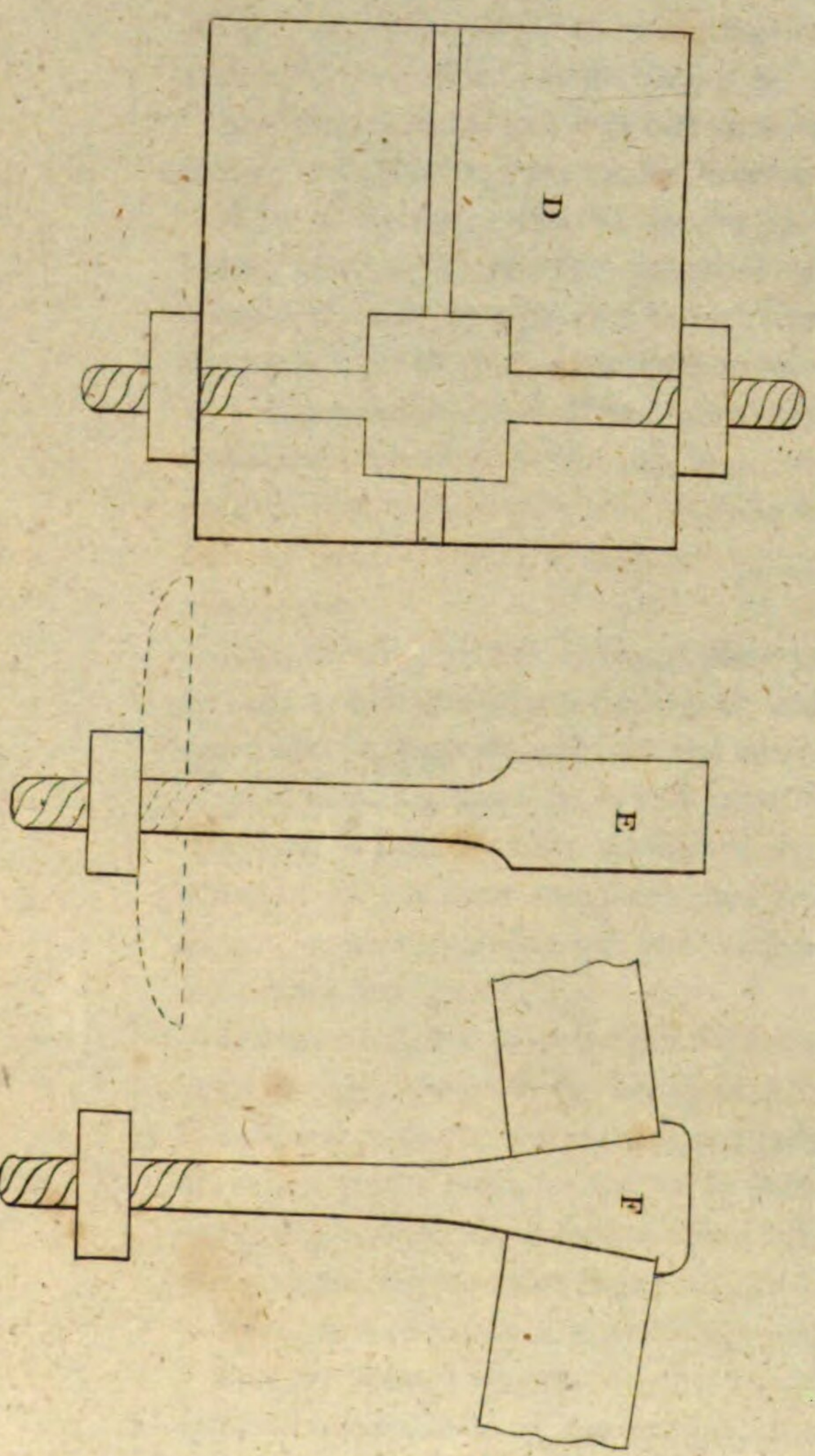
Alſo, in bridging floors, do not place your binding or ſtrong joiſt above three, four, or five feet apart, and that your bridging or common joiſts are not above ten or twelve inches apart, that is, between one joiſt and another.

Alſo, in fitting down tie beams upon the wall plates, never to make your cocking too large, nor yet too near the outſide of the wall plate, for the grain of the wood being cut acroſs in the tie beam, the piece that remains upon its end will be apt to ſplit off, but keeping it near the inſide will tend to ſecure it. See plate 32, at the bottom, where the dimenſions are figured.

Likewiſe obſerve, never to make double tenents for bearing uſes, ſuch as binding joiſts, common joiſts, or purlines; for, in the firſt place, it very much weakens whatever you frame it into, and in the ſecond place it is a rarity to have a draught in both tenents, that is, to draw both joints cloſe, for the pin in paſſing through both tenents, if there is a draught in each, will bend ſo much that, without it is as tough as wire, it muſt needs break in driving, and conſequently do more hurt than good.

Roofs will be much ſtronger if the purlines are notched above the principal rafters, than if they are framed into the ſide of the principals; for by this means, when any weight is applied in the middle of the purline it cannot bend, being confined by the other rafters, and if it do, the ſides of the other rafters muſt needs bend along with it, conſequently it has the ſtrength of all the other rafters ſide-ways added to it.

Plate 40.



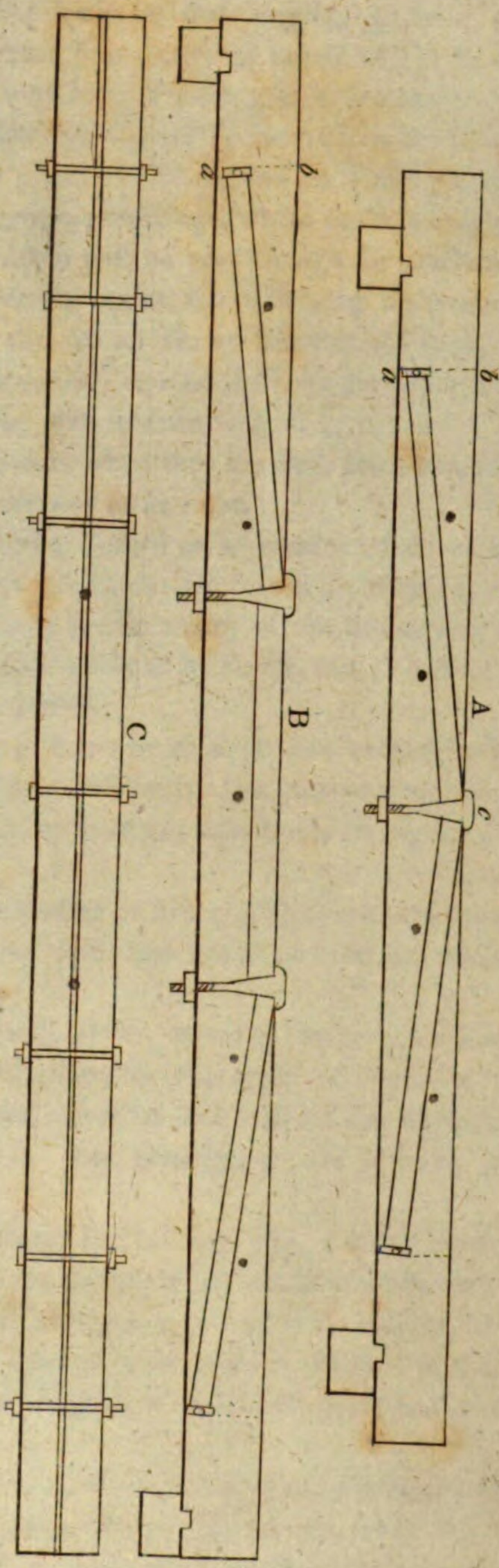


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Plate 41.

Fig. A.

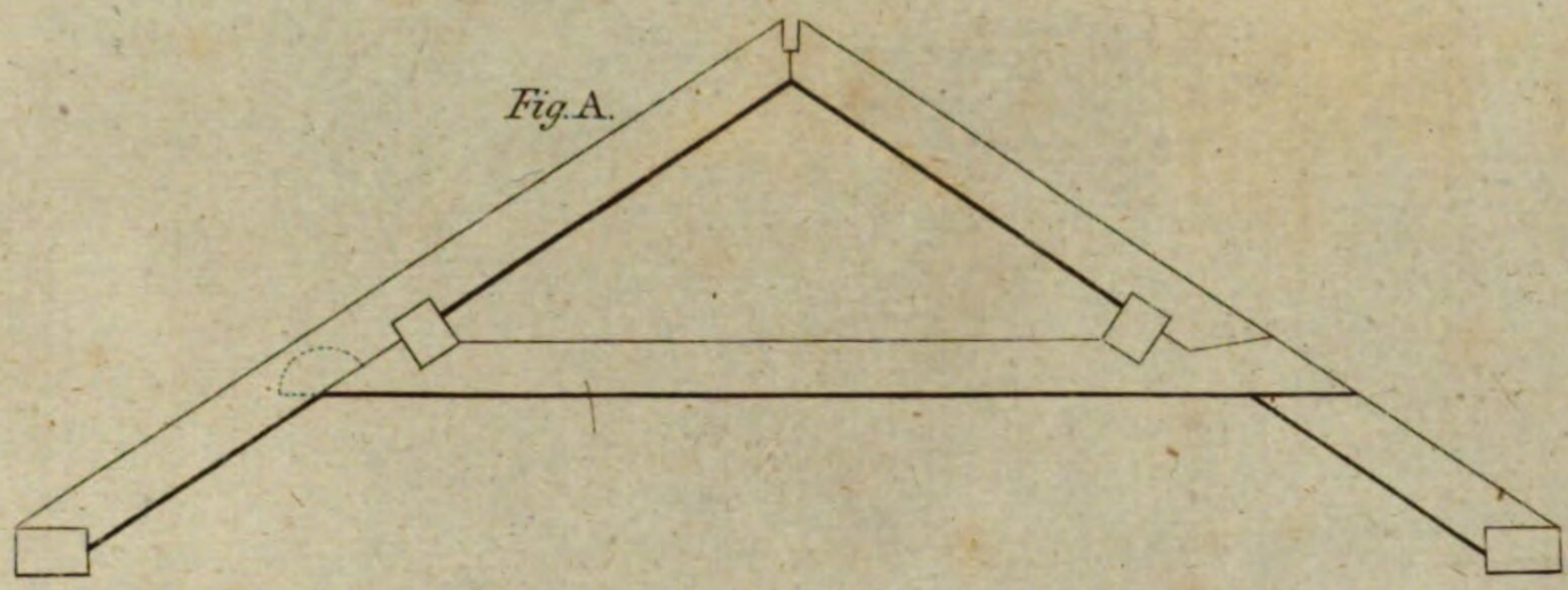


Fig. B.

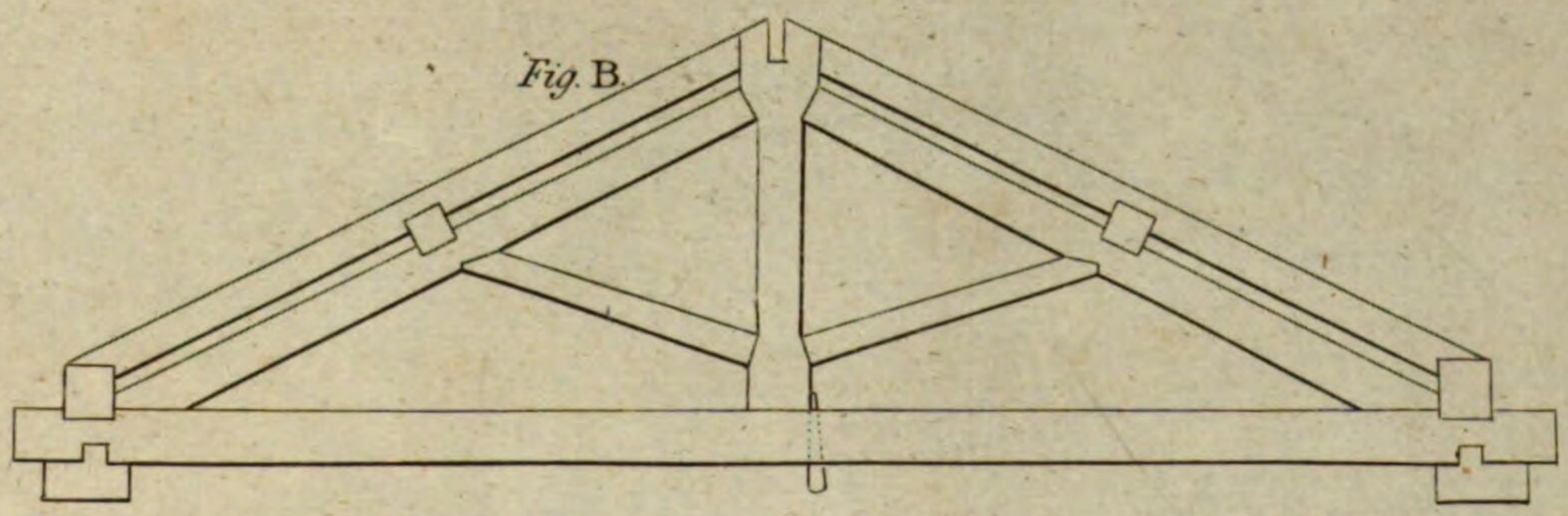
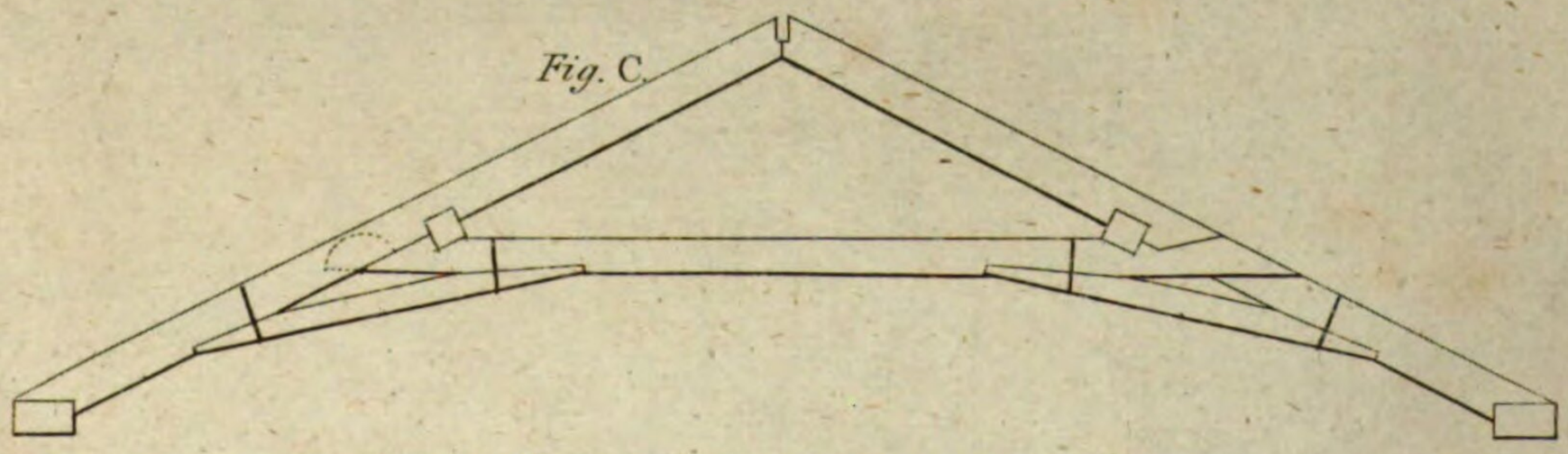


Fig. C.



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PRACTICAL CARPENTRY.

PLATE XL.

A and *B* ſhews the method of truſſing girders, as is uſed by the greateſt maſters at this time.

C is a horizontal ſection of *B*.

D is a ſection of the butment, by cutting acroſs *a b* in *A*.

E and *F* ſhews the two ſides of the king-bolt, at *c* in *A*, which is made with a wedge-way upon the top, ſo that it may force out the truſſes upon the butments.

To tighten the girders.

Your truſſes ought to be let cloſe in to the ſides of the girder, about an inch and a half on each ſide, and the head of your king-bolt ought to be greaſed, ſo that it may ſlide freely paſt the ends of the truſſes; firſt ſcrew your girder cloſe ſideways, then proceed to turn the nut of the king-bolt, and another perſon to hit the head at *c* of the king, with a mallet, which will make it ſtart every time it is hit, and give freſh eaſe at every turning of the nut, ſo that you may camber the girder to any degree that you ſhall have occaſion for, but generally not above an inch in twenty feet.

Note. The ſections *D*, *E*, and *F*, are to one eighth part of the real ſize.

PLATE XLI.

This contains the moſt ſimple conſtruction of roofs.

FIG. *A* is calculated for a ſmall building; at one end of the colar-beam is the Carpenters' boaſt, what they term a dove-tail tenent; but I think rather a rule joint, as it is worked out to a centre. This roof will do for an extent of 20 or 25 feet.

FIG. *B* is a truſs for a roof, the purlines to be notched upon the principal rafters, as will be deſcribed in the following plates of ledgment roofs: this roof may be well calculated for an extent of 30 or 35 feet, the height one fourth of the ſpan for ſlate coverings.

FIG. *C* is a ſimple conſtruction of a roof, for the ſegment finiſh of a dome, which will anſwer to any of the above extents.

PLATE

PLATE XLII.

FIG. *A* is a roof for the purlines to be framed in, and the common rafters to come fair with the principals.

FIG. *B* is a roof calculated for a greater extent than any of the foregoing roofs, and may well extend 50 or 60 feet. Here likewiſe is ſhewn the connection of the roof in the walls.

FIG. *C* is a roof ſupported by two queens, inſtead of a king, to give room for a paſſage or any other conveniency in the roof.

PLATE XLIII.

This roof is calculated for a ſpan of ſeventy or eighty feet.

You will obſerve in this, and the foregoing roofs, that the truſſes are the ſame in number as the purlines which they have to ſupport; for how abſurd it is to give a roof more ſtrength than neceſſary; but, on the other hand, the conſequence will be dangerous if too weak.

FIG. *A* is a deſign of a roof for a theatre, which may extend from 80 to 90 feet.

As it happens frequently in buildings that walls run acroſs the roof, in ſuch caſes there will be little occaſion for truſſing the roof; then the purlines may be truſſed, which will ſave one or two pair of principals, which is a conſiderable advantage.

FIG. *B* is a roof of this kind, which ſhews the ends of the purlines, and *C* ſhews how to truſs the purline.

D, *E*, and *F*, are the methods of ſcarfing timber.

PLATE XLIV. is explained on the Plate.

PLATE XLV.

FIG *A* is a curb roof, with a door in middle of the partition; the beam *a b* to run quite acroſs the pole plate, to be tenented into the beam at *a* and *b*; the ſtory poſt *a c* and *b d* likewiſe to be let in with a ſmall tenent to the beam, as it ſhould project about an inch on each ſide of the beam, to take the ſhoulder of the pole plate, which will diſcharge the weight from the tenent.

FIG. *B* is a roof calculated for two rooms.

FIG. *C* ſhews the method of framing a bridge floor.

Plate 42.

Fig. A.

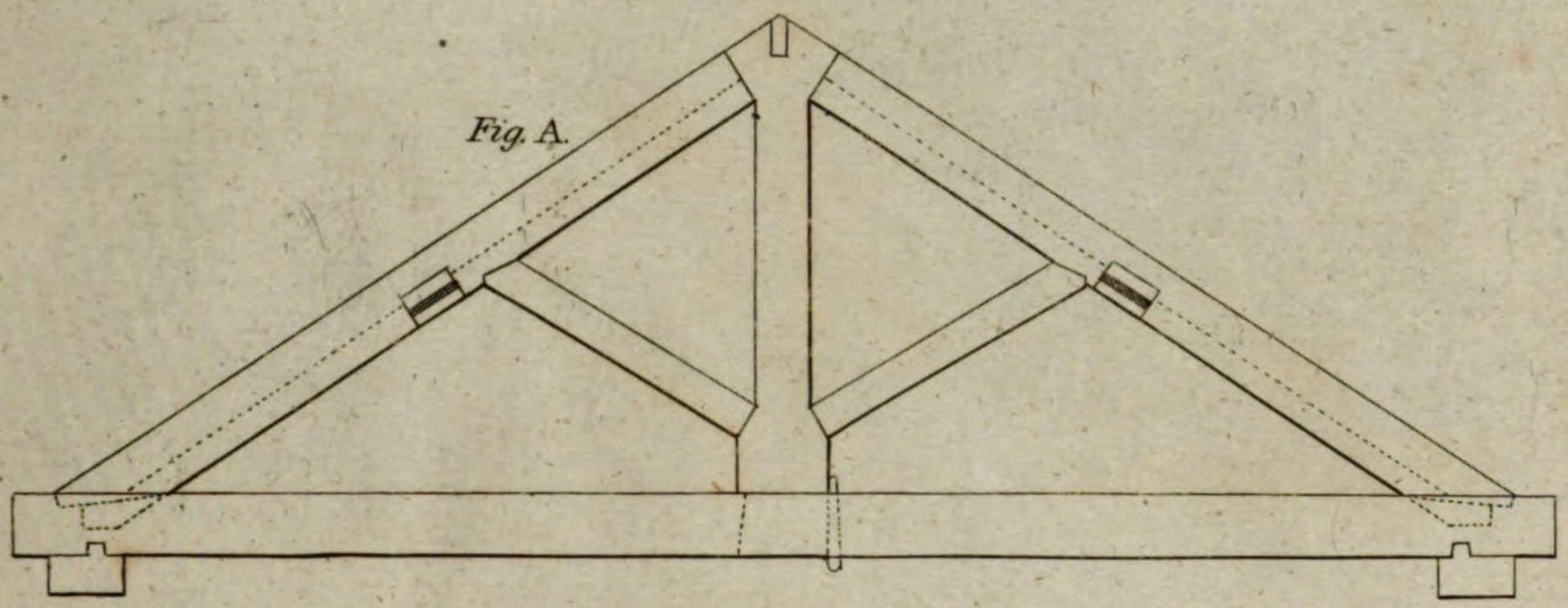


Fig. B.

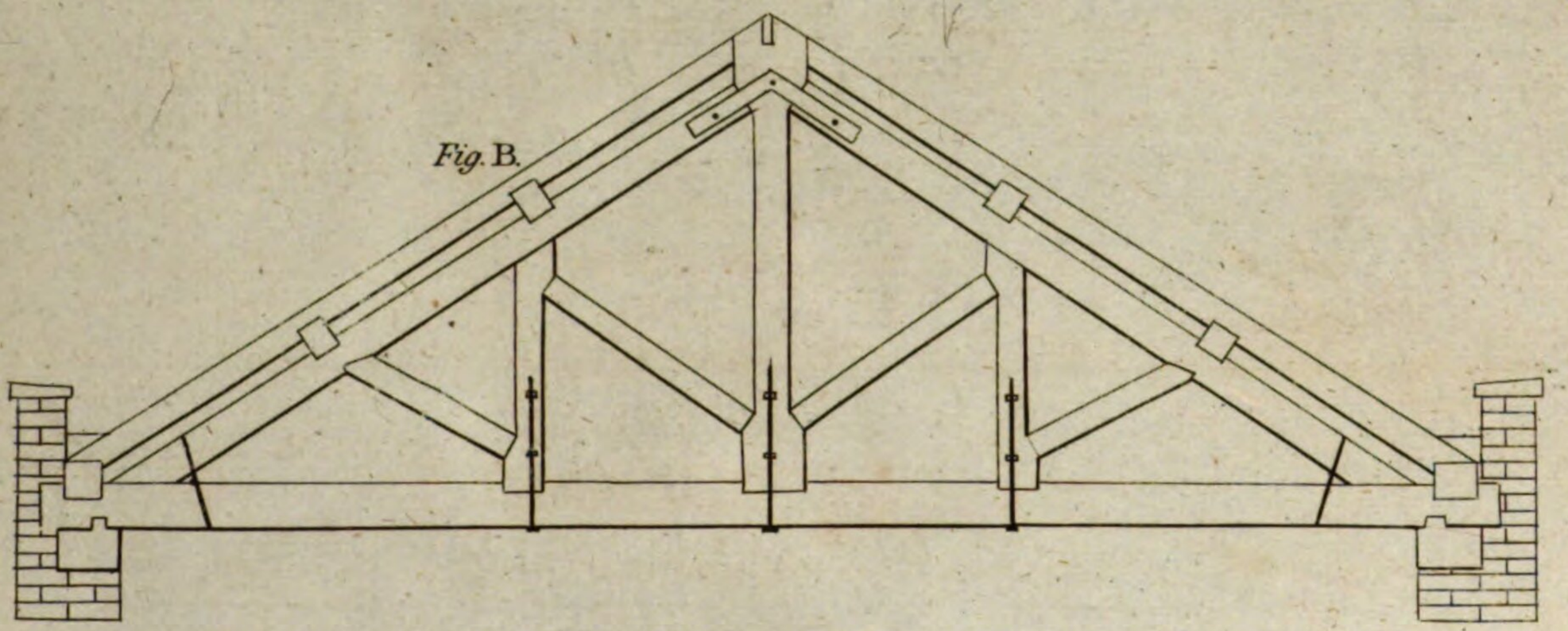
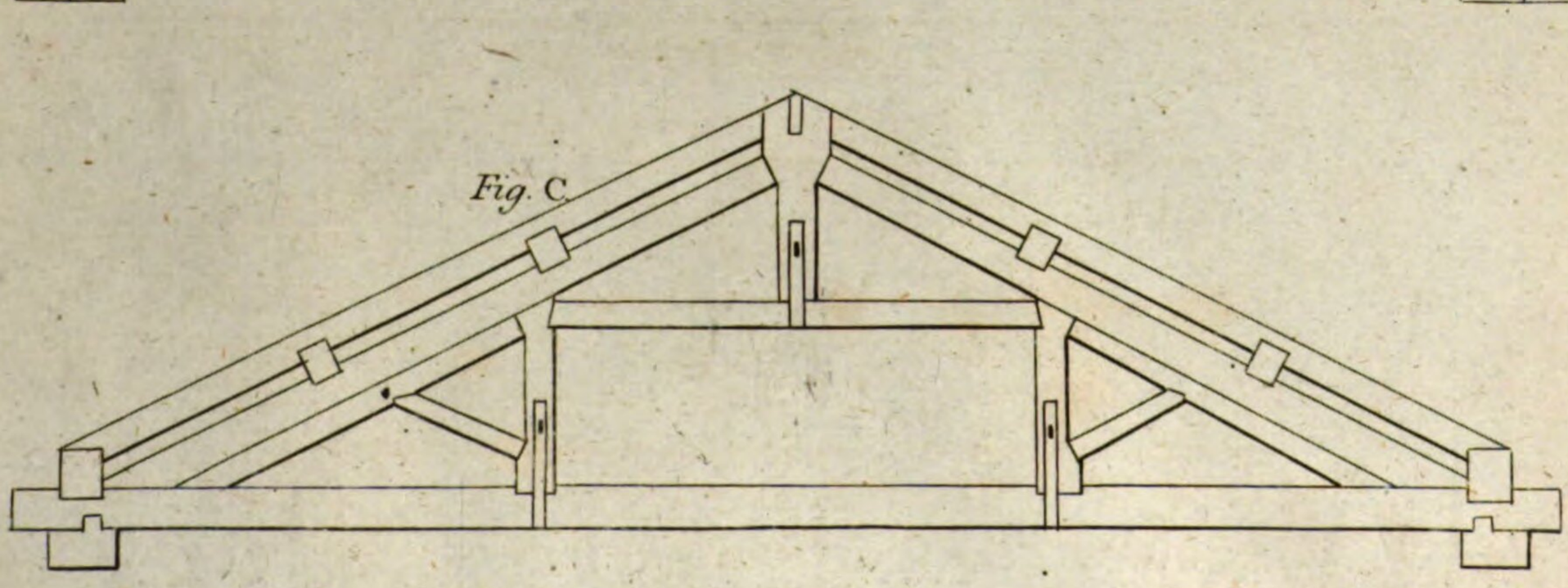


Fig. C.



Pub.d as the Act directs June 9 1792 by P Nicholson.

Plate 43.

Fig. A.

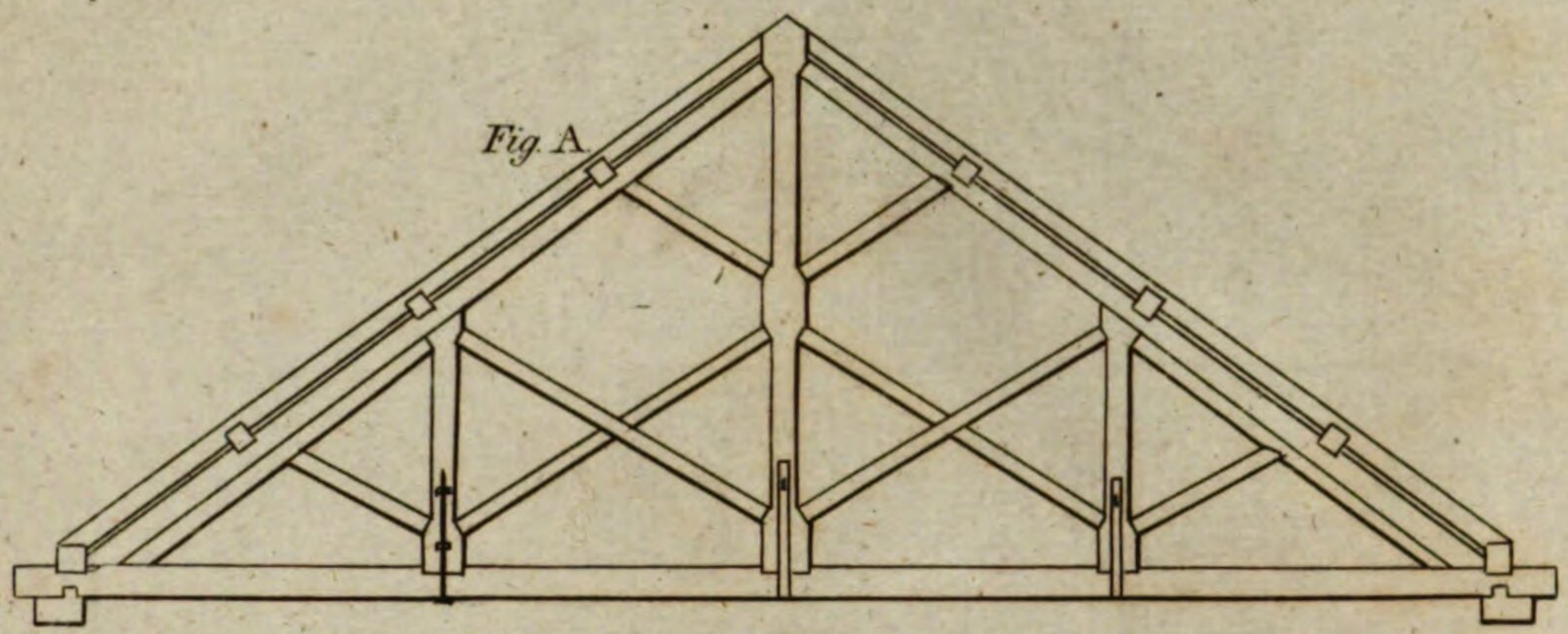


Fig. B.

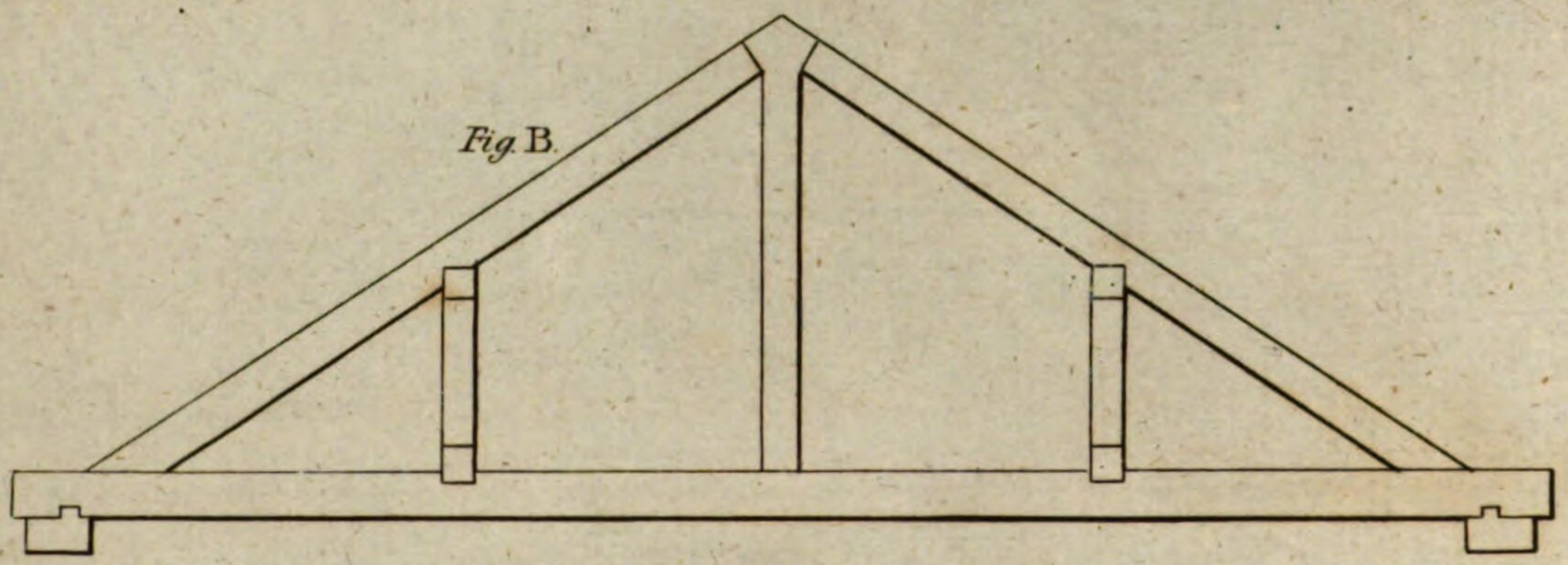


Fig. C.

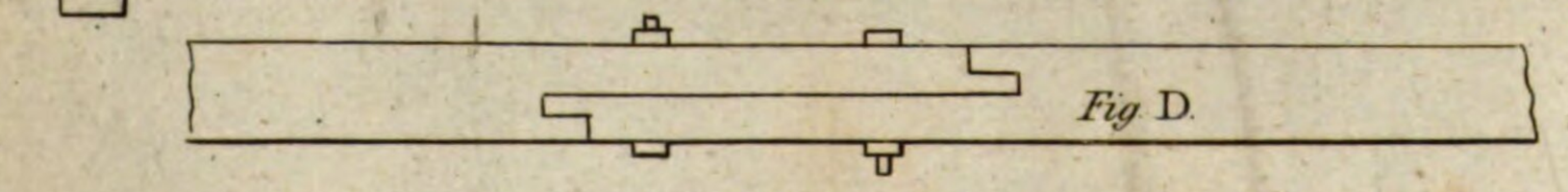


Fig D.

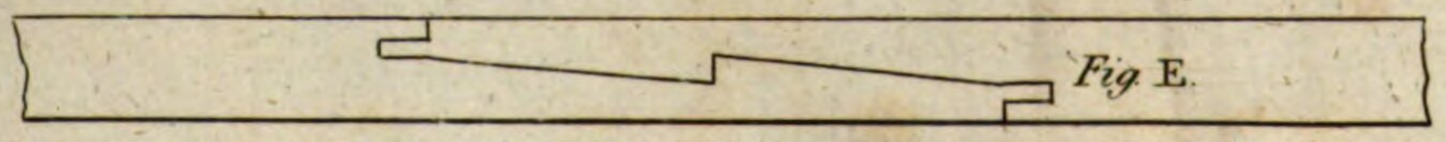


Fig E.

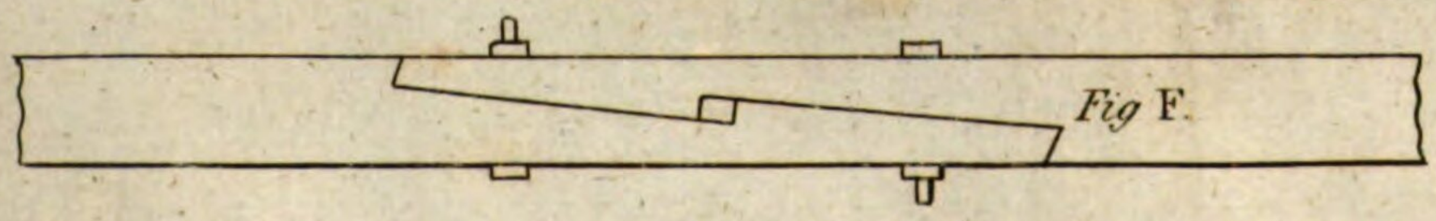


Fig F.

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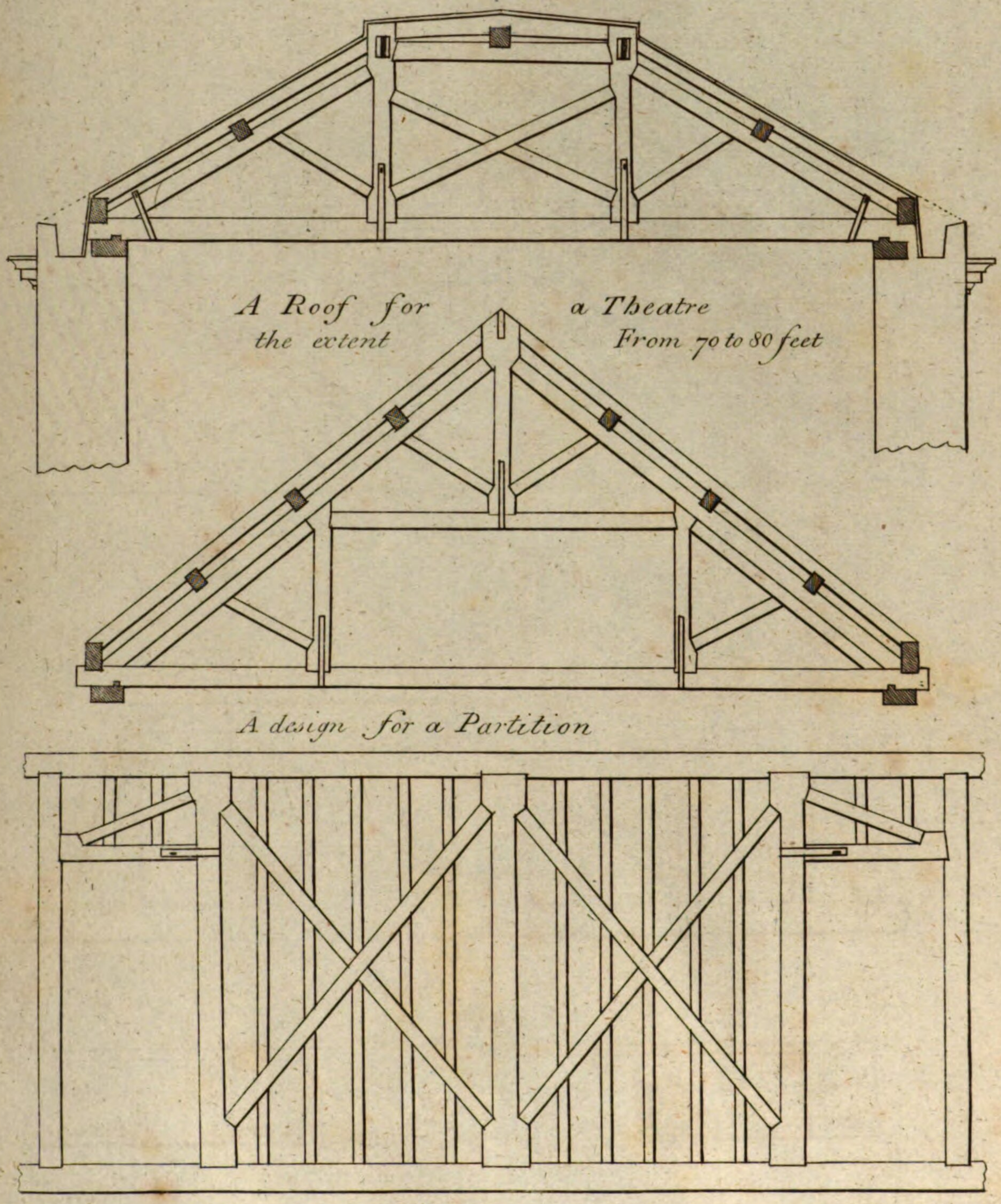
Plate 44.

A design of a roof to Finish with the parapet when covered in, the extent from 30 to 40 feet



A Roof for the extent

a Theatre From 70 to 80 feet

A design for a Partition

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Plate. 45.

Fig. A.

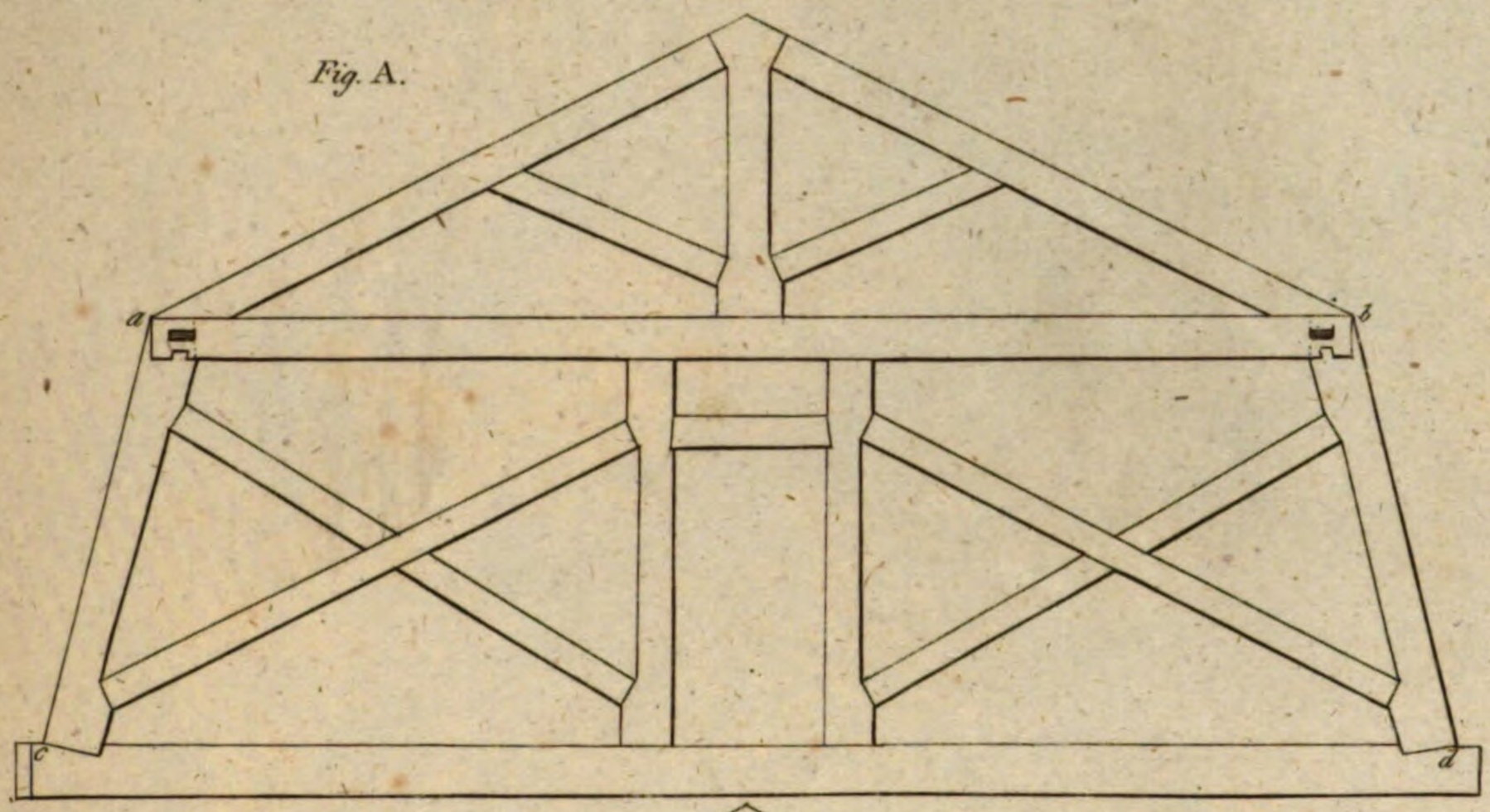

Fig. B.

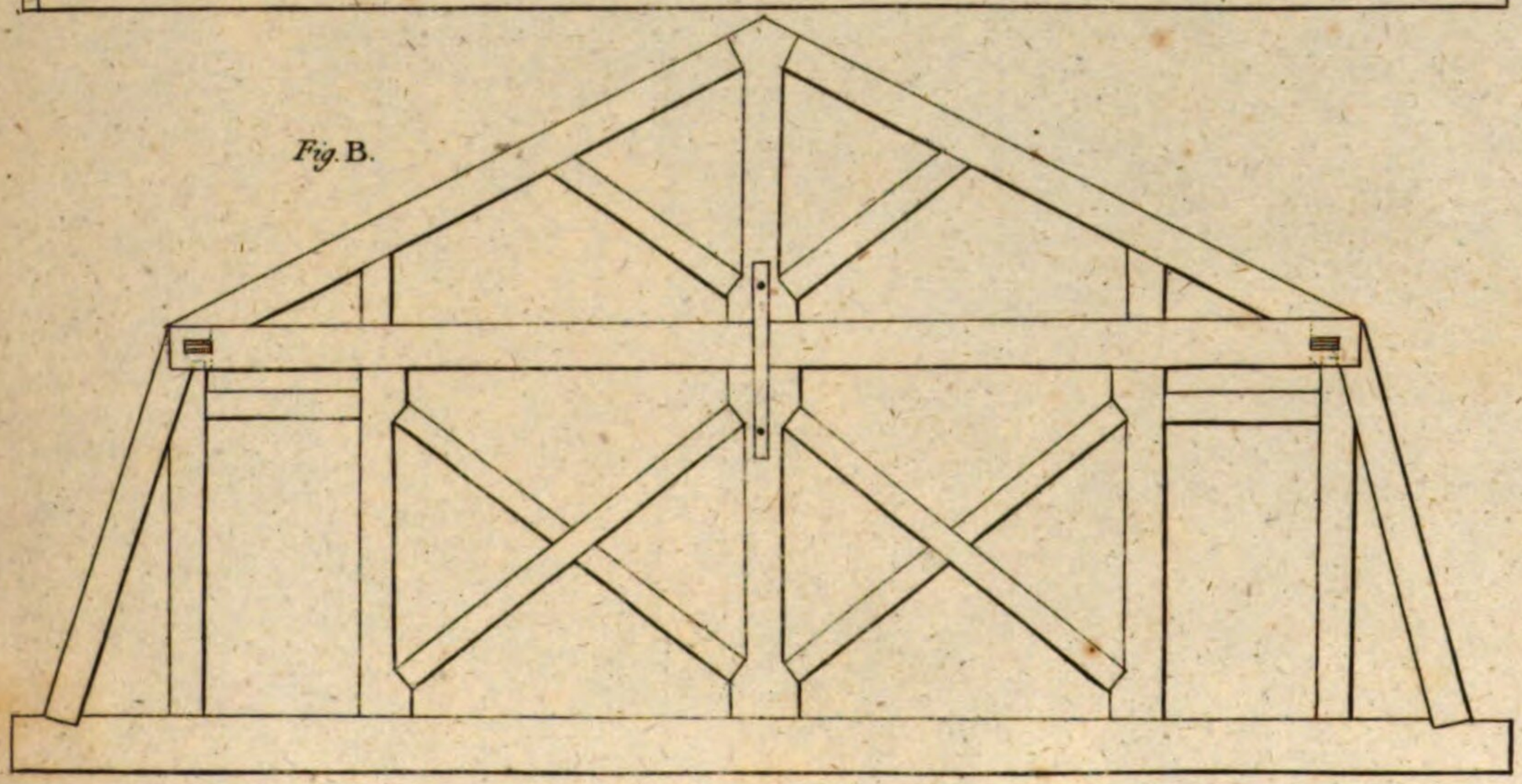

Fig. C.

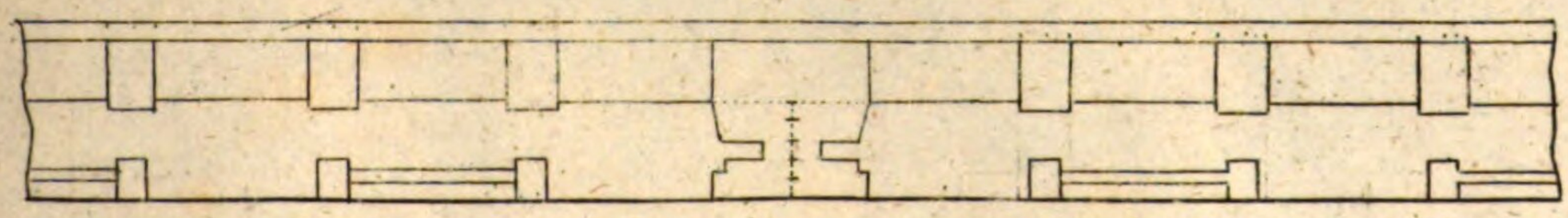

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Plate 46

Fig. A

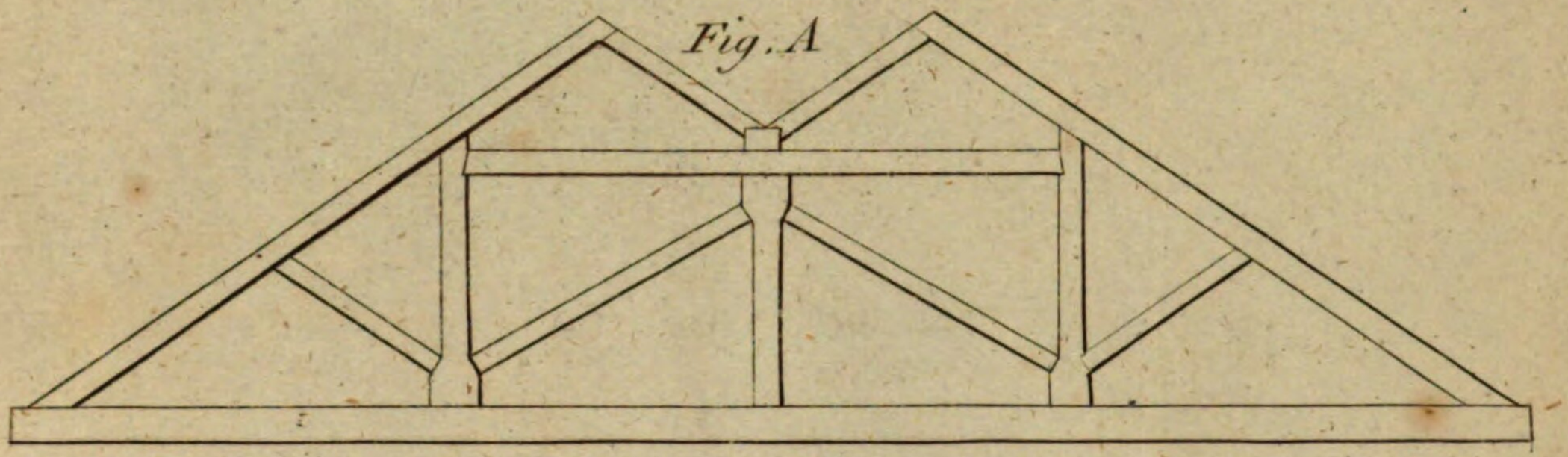

Fig. B

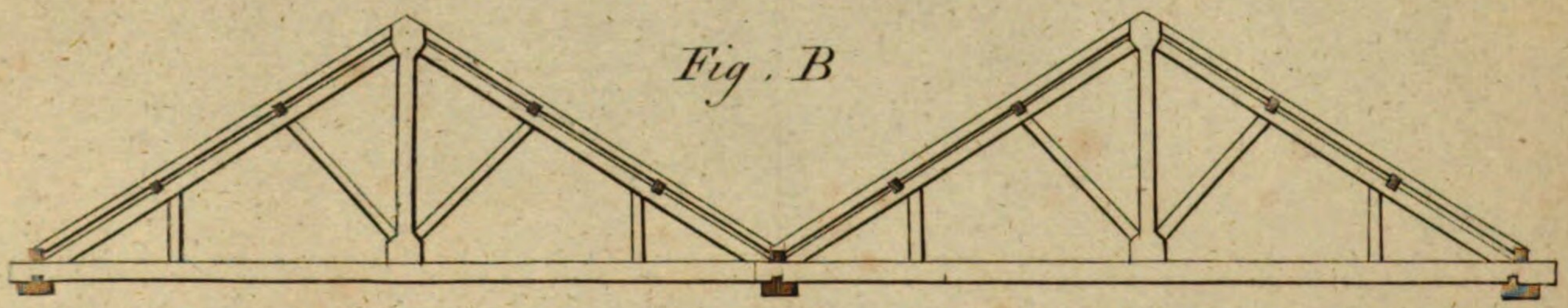

Fig. C

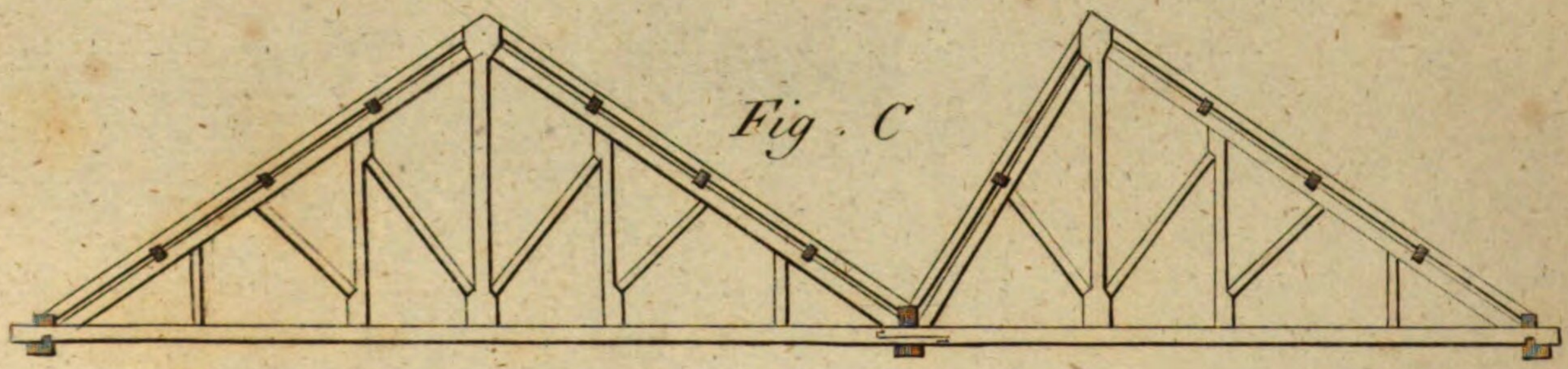

Fig. D

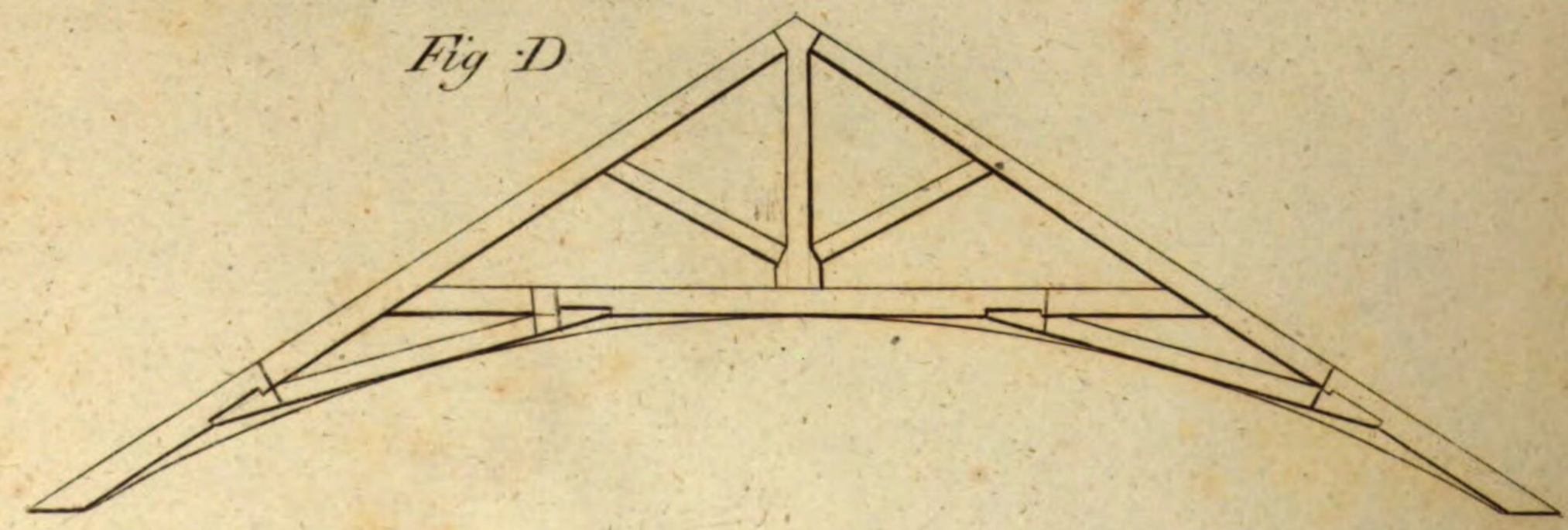

Plate 47

Fig A

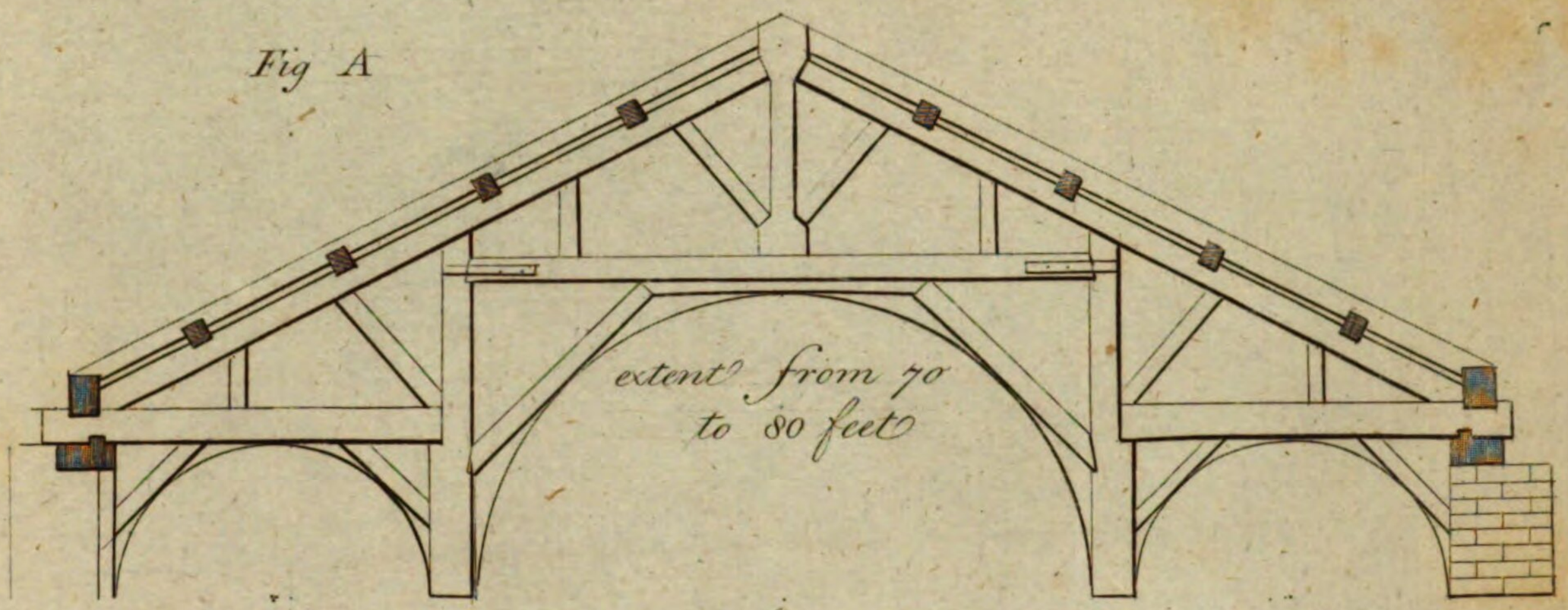

Fig B

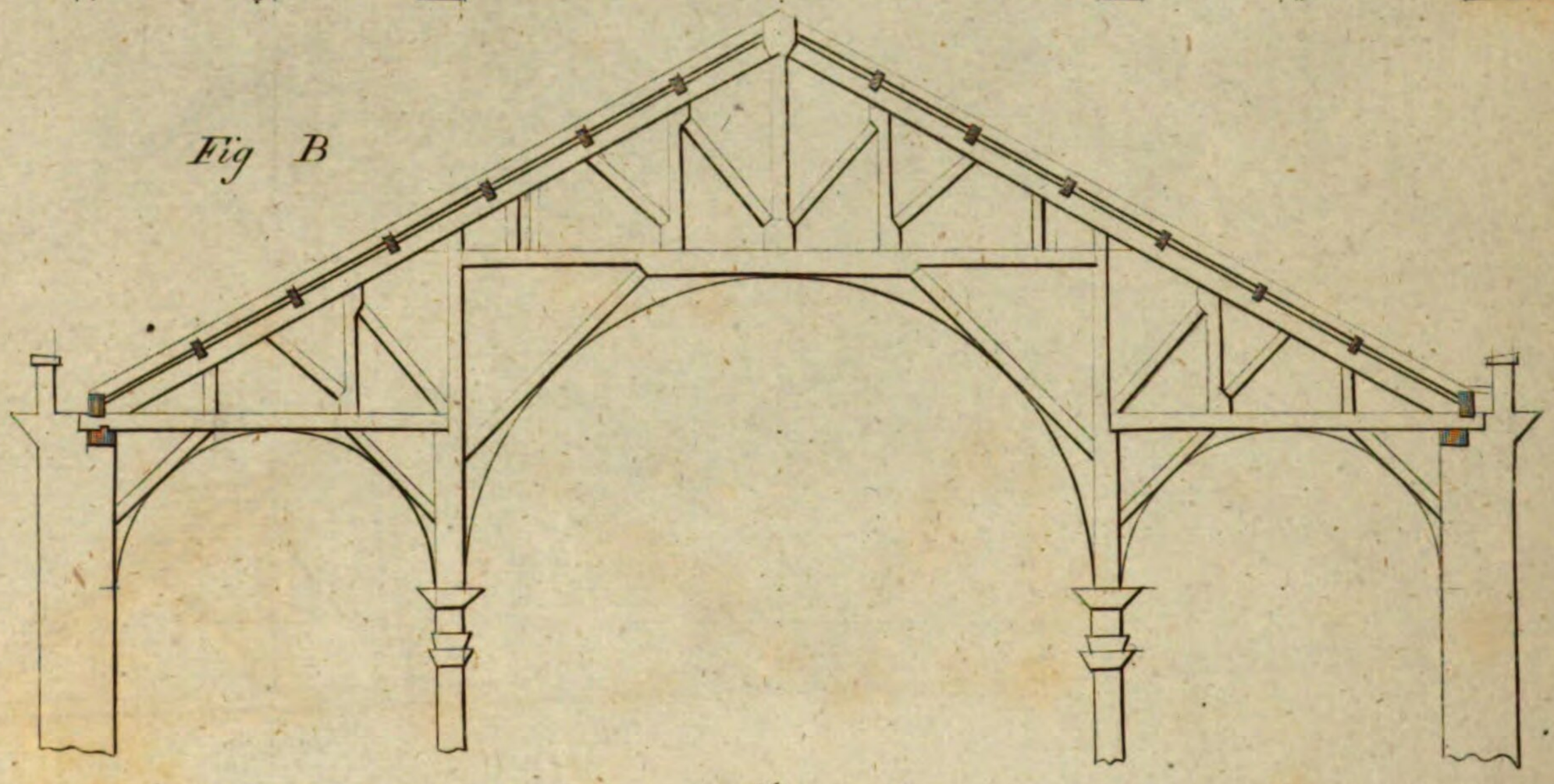

Fig C

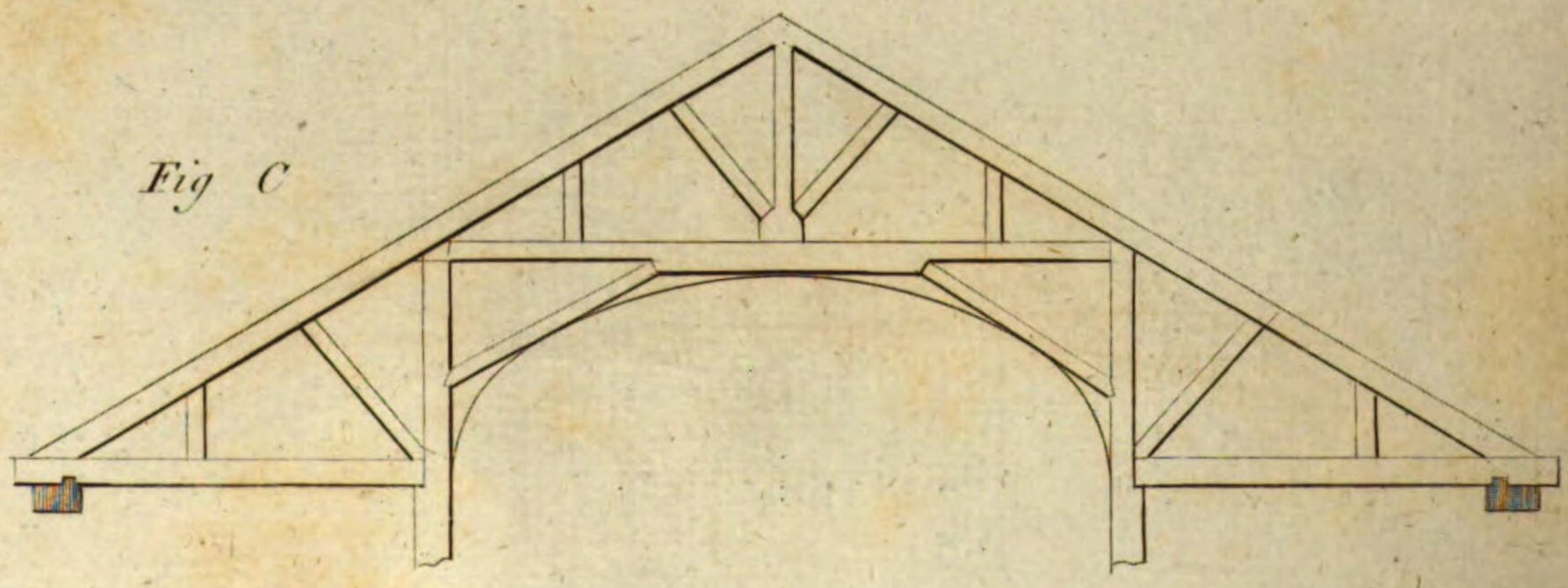

Plate 48.

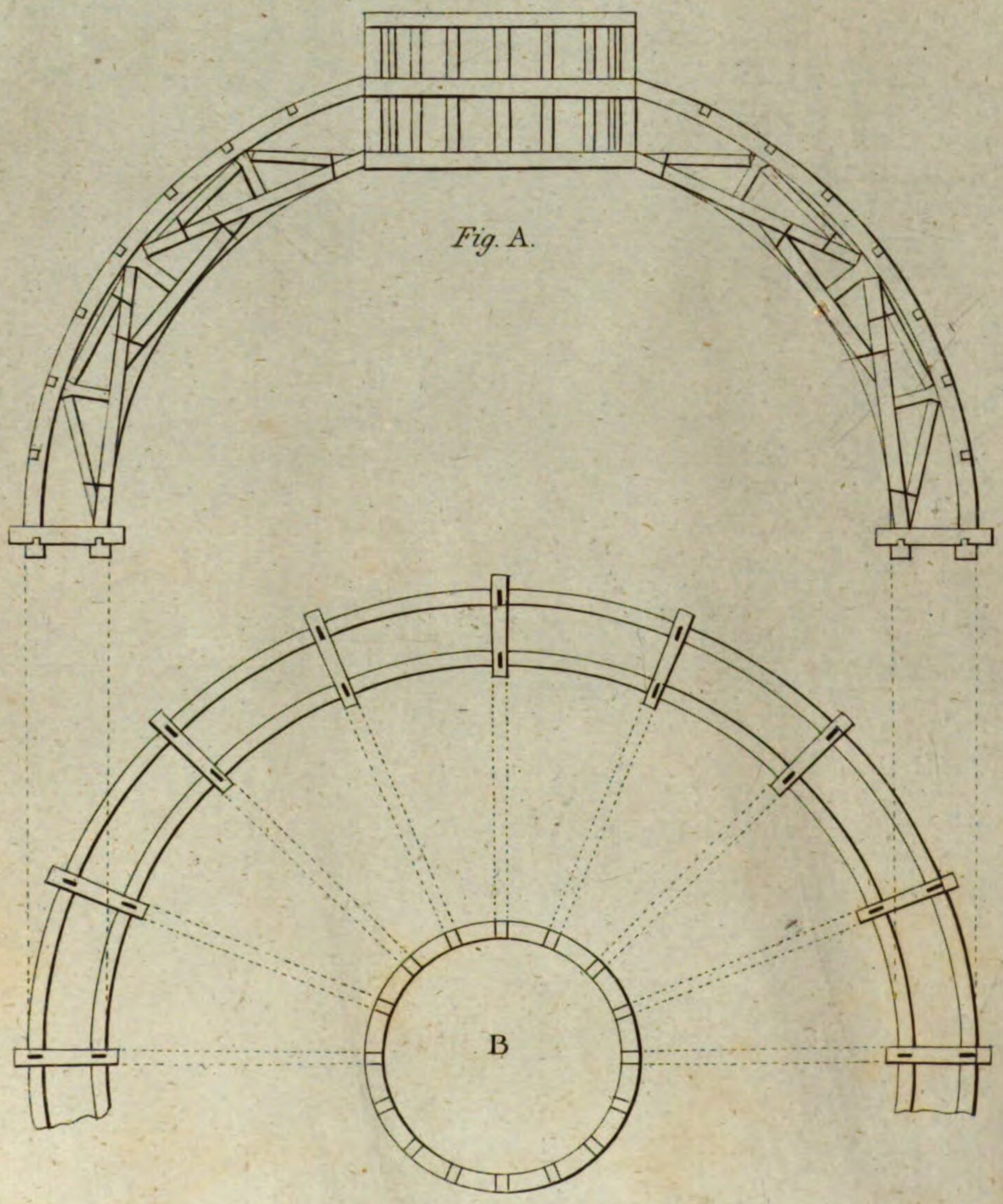

Fig. A.

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Plate 49

Fig A

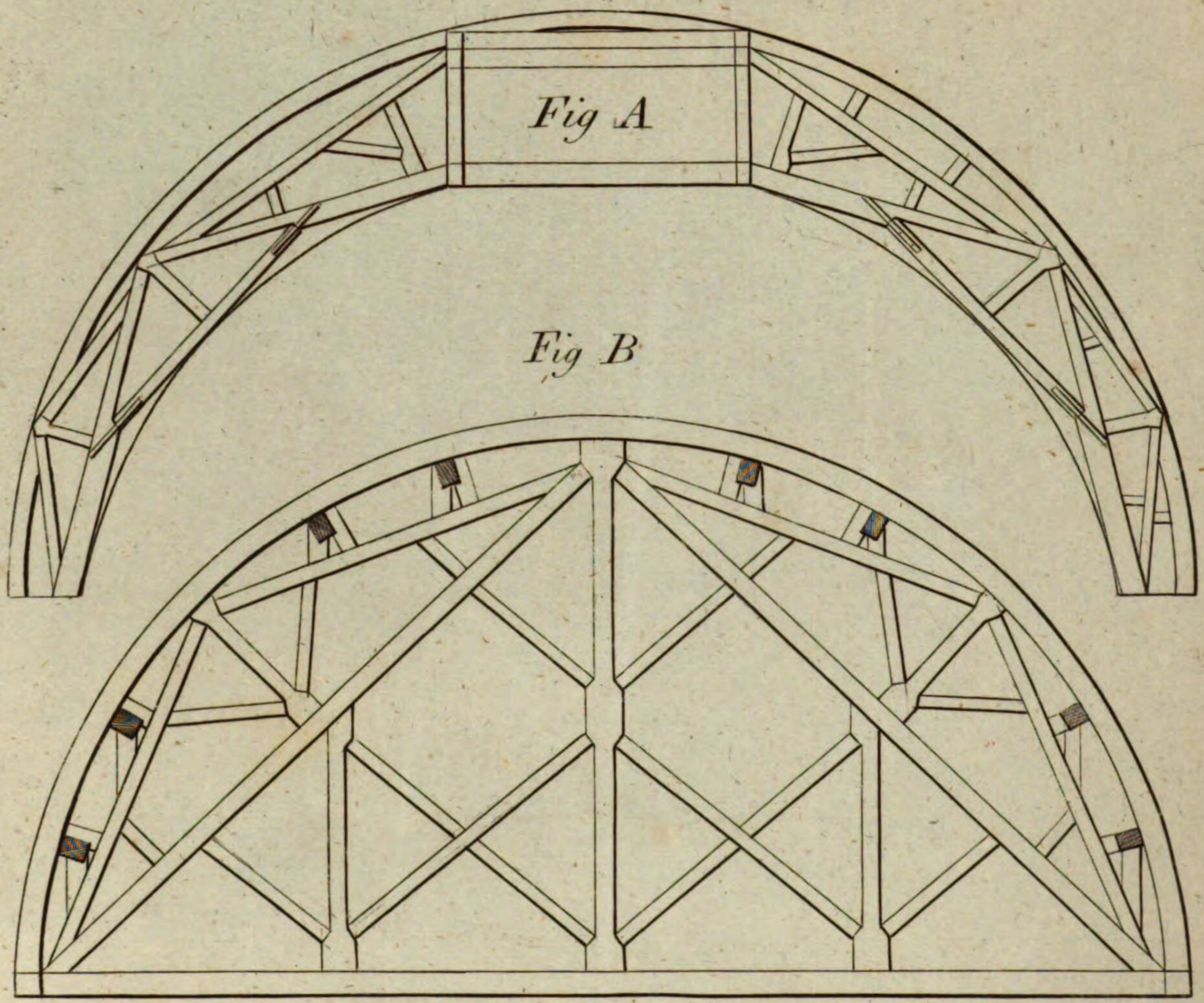


Fig B

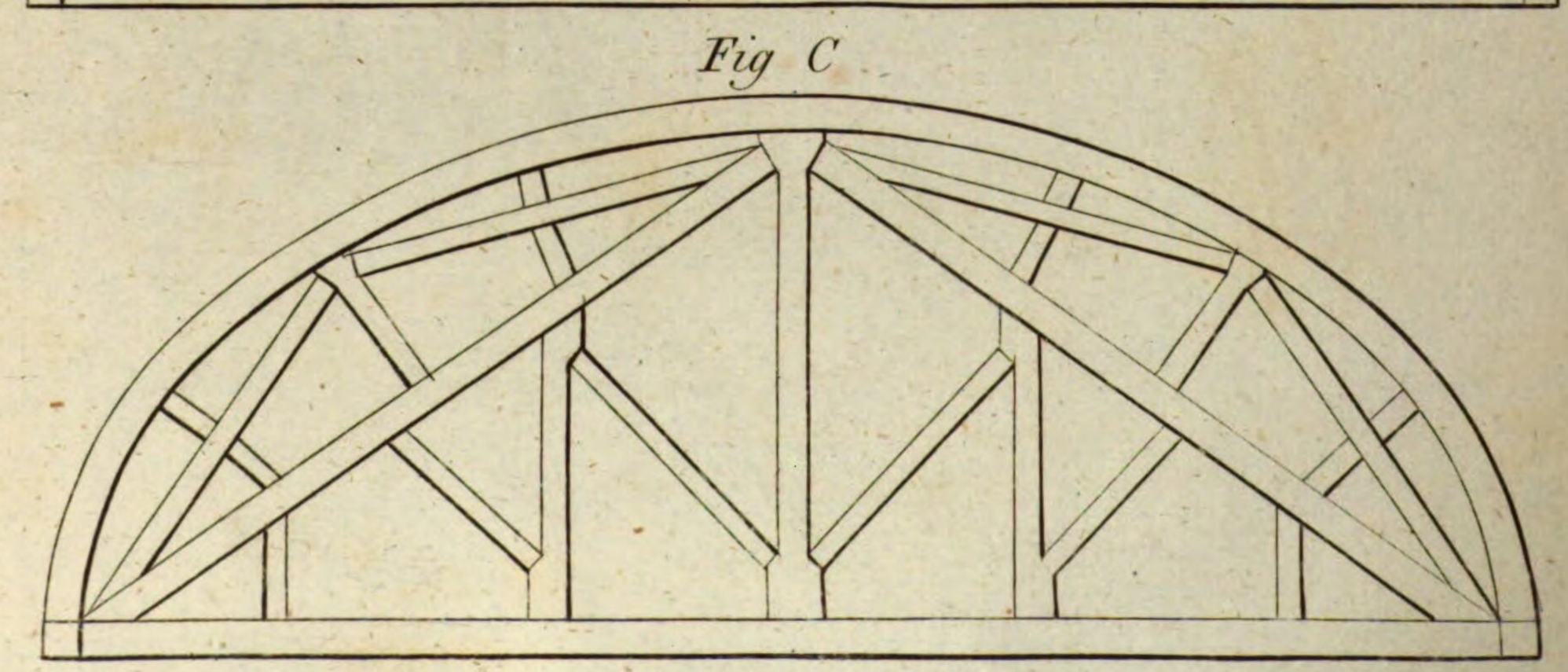


Fig C

Plate 50

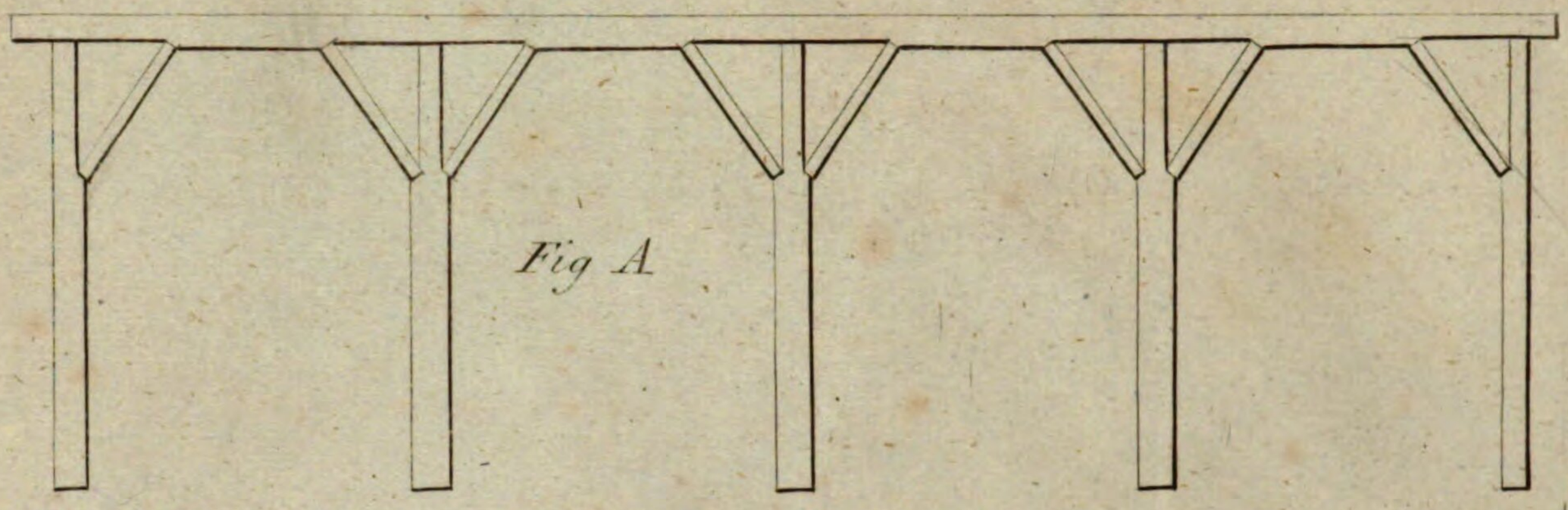
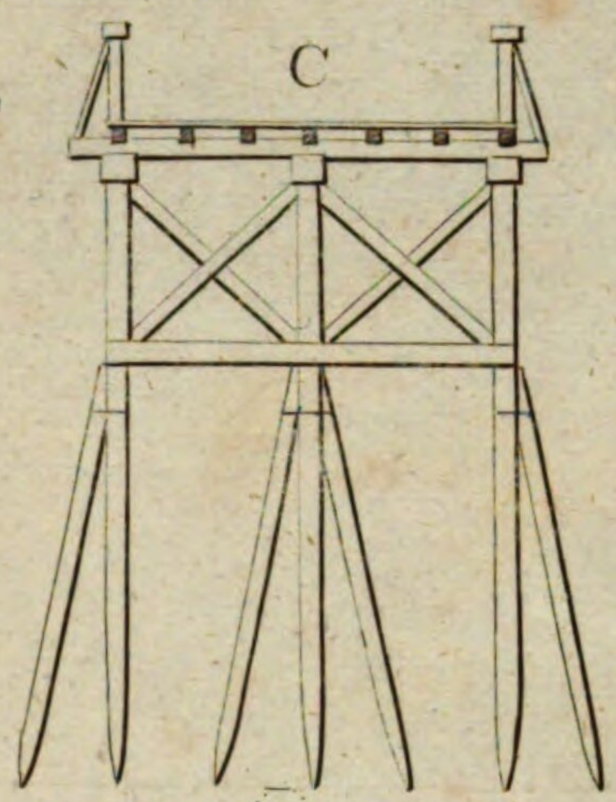


Fig A



C

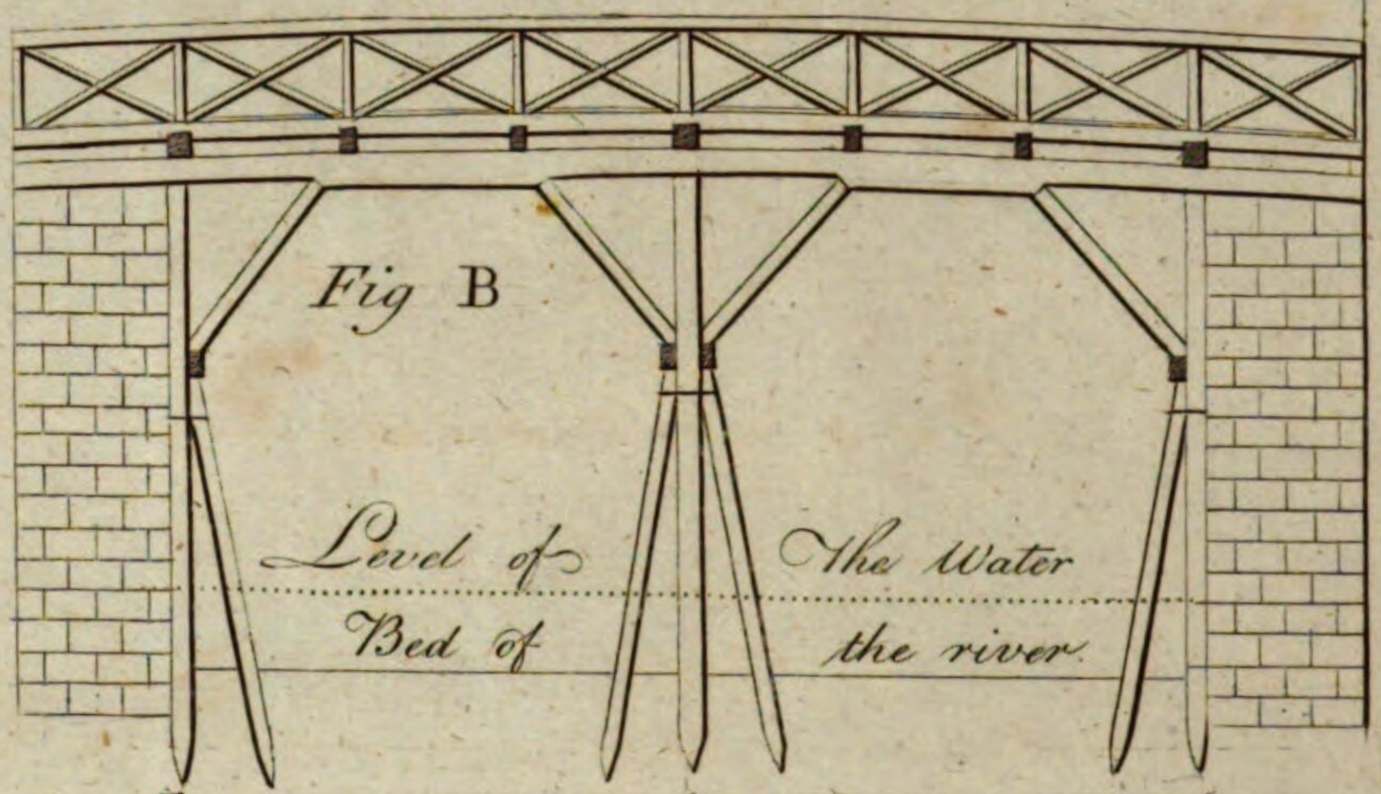
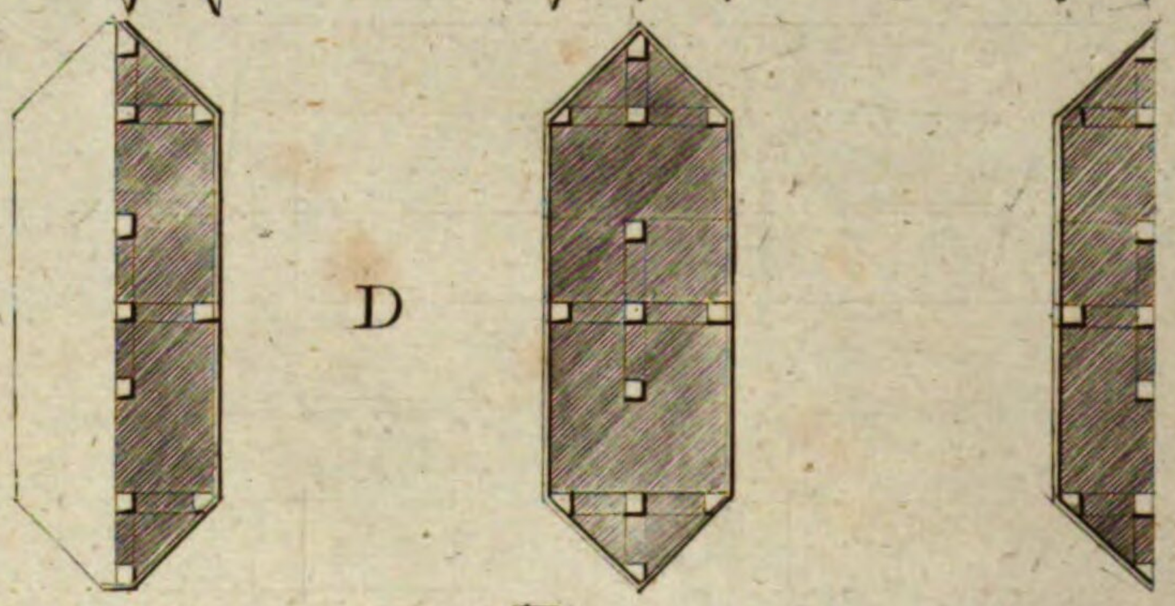
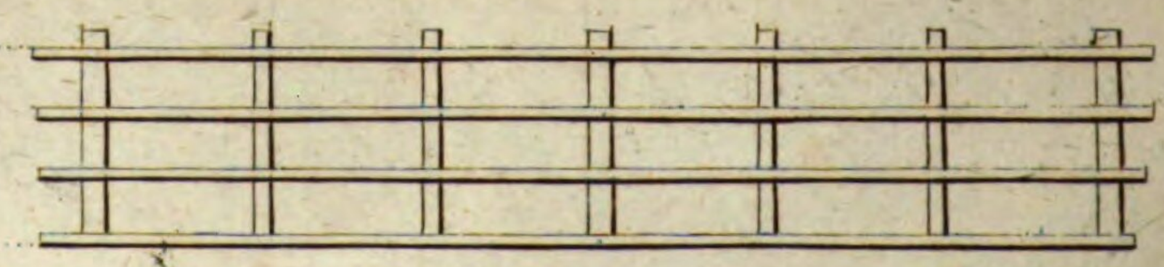


Fig B



D



E

PLATE XLVI.

FIG. *A* is a deſign of an M roof, which is uſeful in ſome caſes where the ſpan is great, and no wall between, and the roof is required not to appear of a great height; but this ſeldom happens in practice, for if there is any wall between the external walls, the roofs are in general made double, as are ſhewn at *figures C*, *B*, and *C*.

PLATE XLVII.

FIG. *A* is a deſign for a church roof, the extent marked on the plate.

FIG. *B* is a deſign of the ſame kind, but may be applied to an extent much greater. Theſe two roofs, when finiſhed, will be the ſame in every reſpect as the Welch groin deſcribed in plate 23; as the manner there ſhewn of fixing the ribs will not be different in this, I refer the reader to the deſcription of that plate.

FIG. *C* is another deſign for a church roof, where the ceiling over the galleries is to finiſh level.

PLATE XLVIII.

FIG. *A* is a deſign for a domical roof; *B* ſhews the manner of framing the curb for it to ſtand upon, the ſection of the curb being alſo ſhewn upon the bottom of *fig. A.*

PLATE XLIX.

FIG. *A* is another deſign for a domical roof; the bottom of it is made into a very narrow compaſs in order to gain room within the dome.

FIGURES *B* and *C* are deſigns for circular and elliptical truſſes for bridges, &c. Theſe truſſes may alſo be applied to roofs where there is no cavity wanting within.

PLATE L.

FIG. *A* is a deſign for a ſtory poſt and breſt-ſummers.

FIG. *B* is a deſign for a bridge. *C* is a ſection acroſs. *D* is part of the plan, which alſo ſhews the manner of fixing the piles. *E* ſhews half the plan of the bridgings.

PART II. Of the Theory and Practice of Joinery.

PRINCIPLES of HAND-RAILS for STAIR-CASES.

I AM now going to enter upon a ſubject, which wants more particularly to be laid down by new methods, than any of the others which I have before touched upon; as the methods laid down by all authors on the ſubject are grounded upon erroneous principles, without any proper foundation, and not conſidering it truly according to its nature. For it is evident, that if a cylinder is any how cut, but not parallel to the baſe, that ſection will be an ellipſis; and if the cylinder is perpendicular, the ſection will alſo be perpendicular to the baſe, or plumb from every point in it to every correſponding point in the baſe or plan: and likewiſe, if you ſuppoſe any other ſection to be cut under the former, and parallel to it, then the ellipſis under will be the ſame as that above; and therefore I ſay, if a mould is made to this ellipſis, let it be drawn upon the upper ſide of a plain piece of wood, of a parallel thickneſs; then if the bevel where the ellipſis cuts the cylinder be applied to either of the extremes upon the edge, and the ſame mould being applied from the rake of that line to the under ſide, then let the plank be cut out between the rake of the upper and under lines; and if this is taken into conſideration, it will appear that hand-rails are the ſections of cylinders, and conſequently the rules for drawing them will be the ſame as thoſe for finding the ſection of a cylinder, which has been explained in the Geometry, ſee plate 9 and its explanation; or if they are made in ſeveral different pieces, they will ſtill be ſome portion of a cylinder, which are all explained in the plate before mentioned.

PLATE LI.

To draw the form of a hand-rail.

In *fig. A* make an equilateral triangle *v w t* upon its width, and divide it into five equal parts, and from one part on each ſide draw *z s* and *y w*, then *t g* and *m* are the centres, *l m* being made equal to *l g*; the centres are found the ſame for the upper ſide.

The form of the rail being given, to draw the mitre cap.

Let the projection of the cap be three inches and a half, and make the diſtance of the inſide circle from the outſide circle the projection of the noſe on each ſide of the rail, and draw the mitre *n o* and *p o*; then continue parallel lines down to the mitre *p o*, put the foot of your compaſs in the centre of the cap, and circle the parallel lines round to *a c e g* and *i*, and draw the ordinates *a b*, *c d*, *e f*, &c. and then prick the cap to the rail according to the letters.

How to draw the form of the cap for the mitre to come to the centre.

It is only drawing the parallel lines from the rail to the mitre wherever it is, and circling them round to the ordinates, and ſo pricked from the rail, and the thing is done.

Plate 51.

Fig. A.

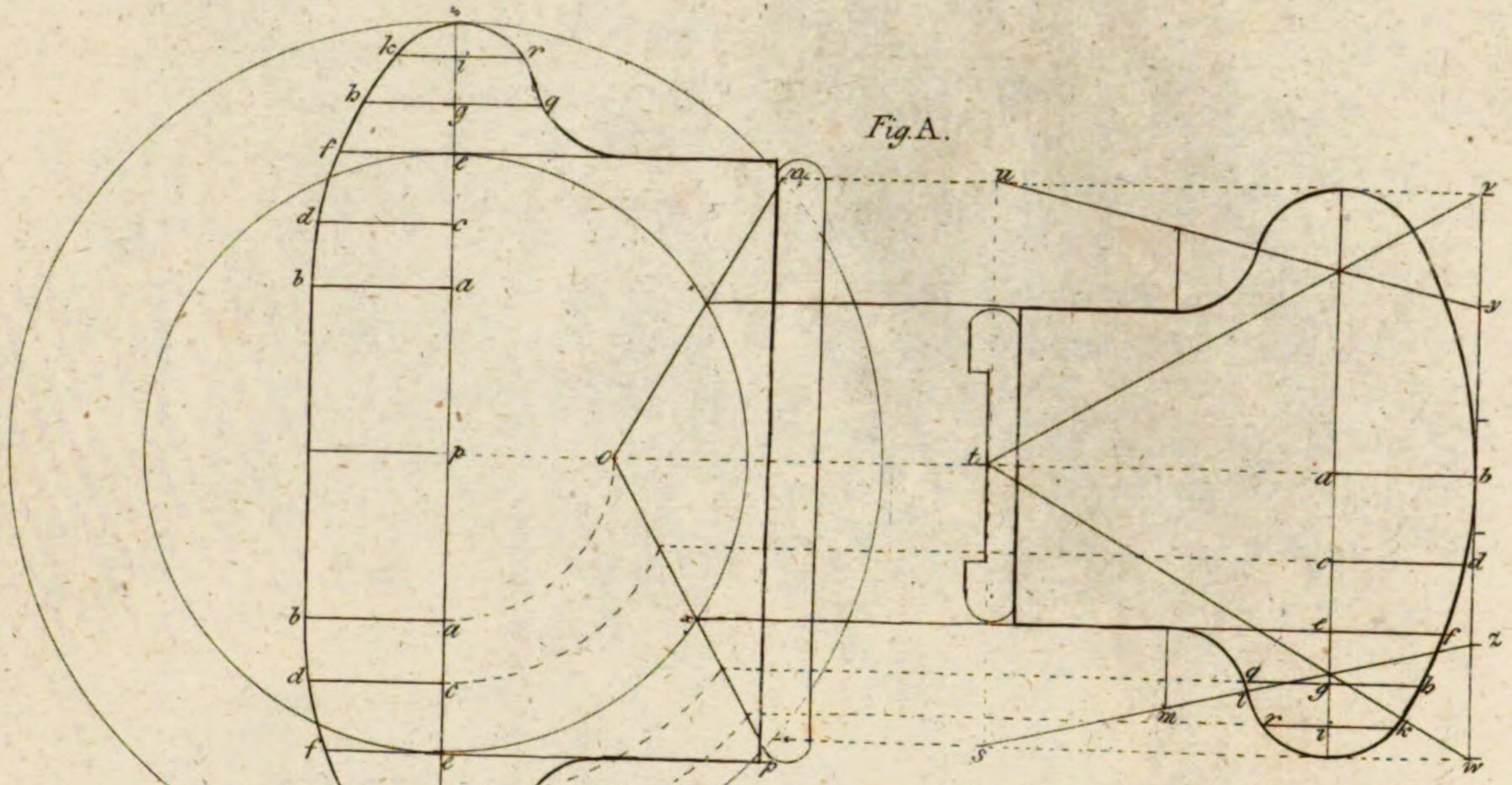
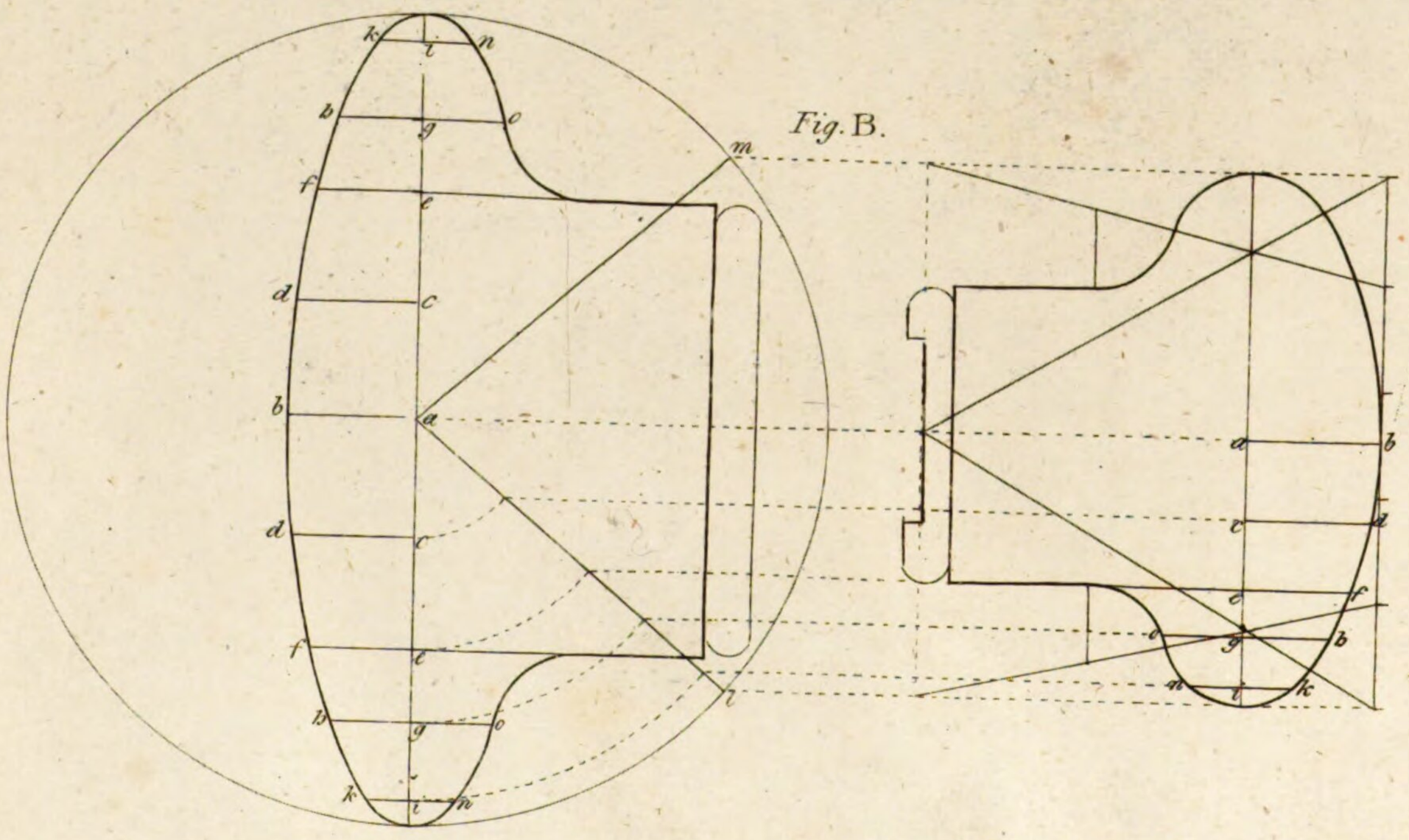


Fig. B.



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To draw the ramp of this stair.
Make a.b equal to a.c. then
draw b.d at right angles to the
Rail. and c.d from the top.
Parallel to the landing. then d
is the center of the ramp

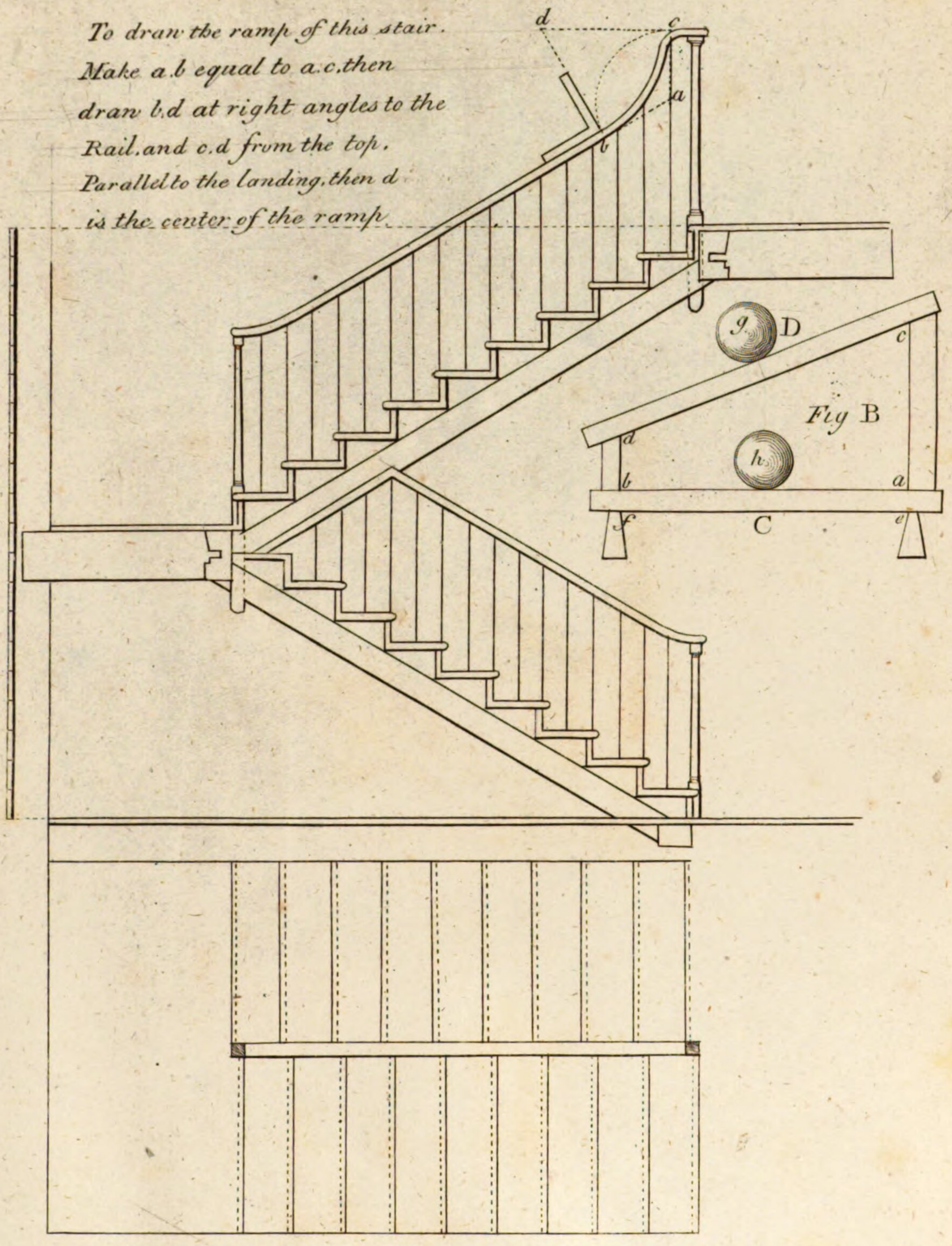

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Plate 53.

A dogleg Stair Case with Winders

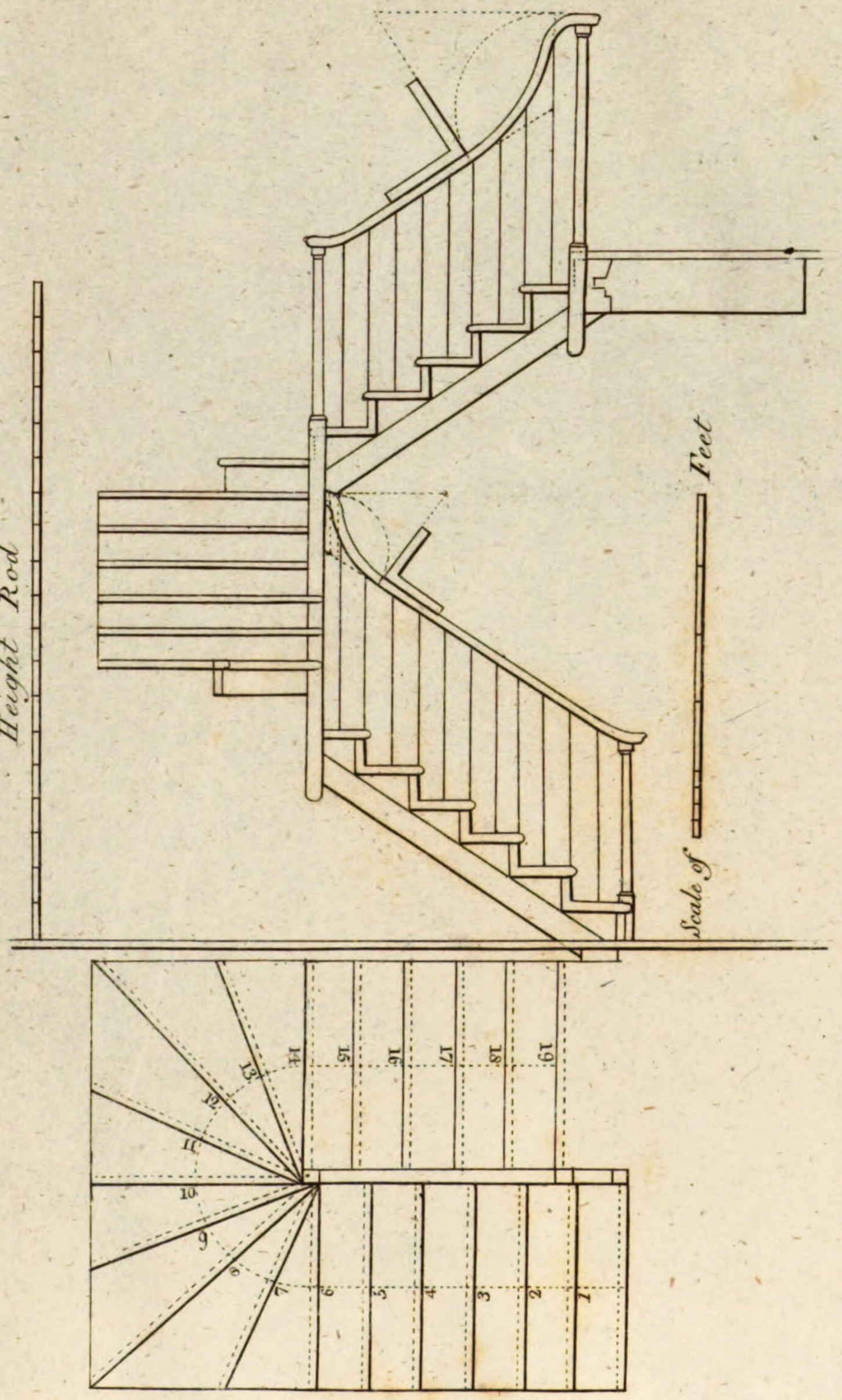

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Plate 54.

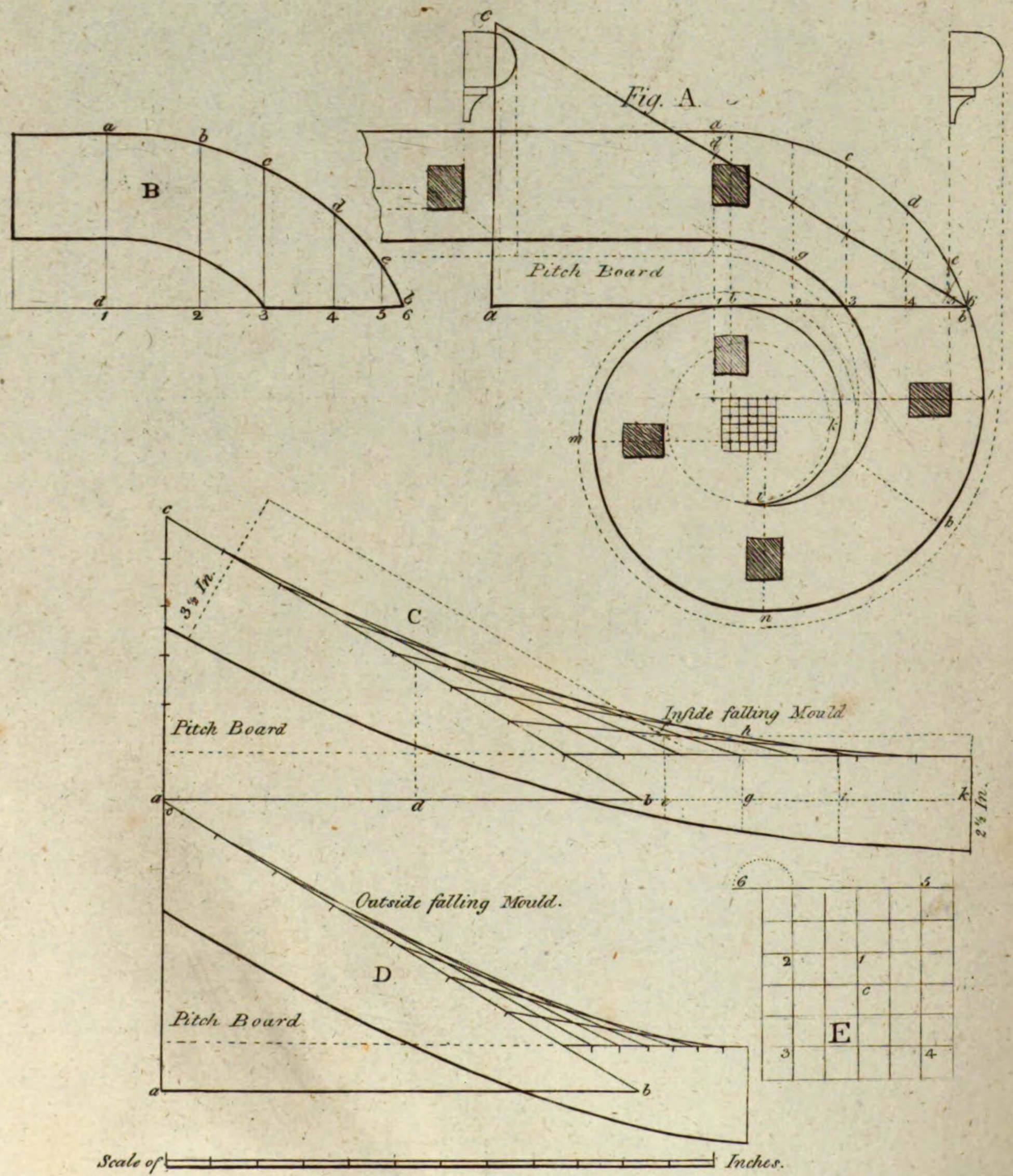

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PLATE LIV.

To draw the ſcroll of a hand-rail.

In *fig. A* make a circle three inches and a half diameter, divide the diameter into three equal parts, and make a ſquare in the centre of the eye to one of thoſe parts, and divide each ſide of the ſquare into ſix equal parts; this ſquare is ſhewn in *E*, at the bottom, in full ſize for practice, and laid in the ſame poſition as the little ſquare above, ſo that the centres may be more readily found, which are all marked in a regular poſition; the centre at 1 draws from *i* round to *k*, the centre at 2 draws from *k* to *l*, and the centre at 3 draws from *l* to *m*, &c. which will complete the outſide revolution at *a*, with the centre *c*; then ſet the thickneſs of the rail from *a* to *f*, and go the reverſe way to draw the inſide; then the ſcroll will be completed.

To draw the curtail ſtep.

Set the balliſters in their proper places on each quarter of the ſcroll in *fig. A*; the firſt balliſter ſhews the return of the noſing round the ſtep, the ſecond balliſter is placed at the beginning of the twiſt, and the third balliſter a quarter diſtant, and ſtraight with the front of the laſt riſer: then ſet the projection of your noſing without, and draw it all round equal diſtant from the ſcroll, which will give the form of the curtail.

To draw the face mould for ſquaring the twiſt part of the ſcroll.

You will obſerve here, that the joint is made at 3, 6, juſt to clear the ſide of the ſcroll; draw ordinates acroſs the ſcroll at diſcretion, to cut the line *d b*, *a b c* being the pitch-board; take notice that lines be drawn from 3 and 6 to meet *d b*, ſo that you may have the ſaid points exact at 3 and 6 in your face mould, then take the line *d b*, and mark the places of the ordinates upon a rod, and transfer the diviſions to *d b* in *B*, then trace *B*, from *fig. A*, according to the marks.

To find the falling mould C.

In *C*, *a b c* is the pitch-board; the height is divided into ſix parts, to give the level of the ſcroll, the diſtance *a d*, is from the face of the riſer to the beginning of the twiſt; and the diſtance from *d* to *k* in *C*, is the ſtretch out from *a*, the beginning of the twiſt round to *b* in *fig. A*; each being any point taken at diſcretion, more than the firſt quarter; divide the level of the ſcroll, and the rake of the pitch-board, into a like number of parts, and complete the top edge of the mould by interſecting lines, and the under edge parallel to it to the depth of the rail.

How to find the parallel thickneſs of ſtuff for the twiſt and ſcroll.

Take the compaſs round *a b c d e*, to 6, in *fig. A*, and ſtretch it out upon the baſe of the pitch-board from *d* to *g*; draw *g h* perpendicular to interſect with the top of the mould; then draw the dotted line *h f*, parallel to the level of the ſcroll both ways; then take the diſtance 6 1, in *fig. A*, that is, the length of the plan, for the twiſt part, and ſet it from *d* to *e* in *C*, and draw *e f* perpendicular, to cut the parallel *f h*; then draw a dotted line through *f*, parallel to *c b*, the longeſt ſide of the pitch-board, which gives the thickneſs of ſtuff for the twiſt, about three inches and a half; and the parallel line from *f* to the baſe, ſhews the thickneſs of the ſcroll.

Note. The falling mould *D*, for the outſide, is found in the ſame manner as the other falling mould *C*.

PLATE LV.

As the method of getting a ſcroll out of a ſolid piece of wood, having the grain of the wood to run in the ſame direction with the rail, is far preferable to any of the other methods, with joints in them, being much ſtronger than any other ſcroll with one or two joints, and much more beautiful when executed, as no joint can be ſeen, and conſequently no difference in the grain of the wood at the ſame place. I ſhall here give you a ſpecimen, the method for deſcribing a ſcroll being already given in the laſt plate; and likewiſe the falling mould.

How to find the raking or face mould.

Place your pitch-board, *a b c*, in *fig. D*, as in the laſt plate; then draw ordinates acroſs the ſcroll at diſcretion, and take the length of the line *d b*, with its diviſions on the longeſt ſide of the pitch-board, and lay it on *d b* in *E*; then the ordinates being drawn in *E*, it will be traced from *fig. D*, as the letters direct.

How to find the parallel thickneſs of ſtuff.

Let *a b c* be the pitch-board, in *F*, and let the level of the ſcroll riſe one ſixth, as in the laſt plate; and from the end of the pitch-board at 6, ſet from *b* to *d* half the thickneſs of the balliſter, to the inſide; then ſet from *d* to *e* half the width of the rail, and draw the form of the rail on the end at *e*, the point *b* being where the front of the riſer comes, then the point *e* will be the projection of the rail before it; then draw a dotted line to touch the noſe of the ſcroll, parallel with *c b*, the longeſt ſide of the pitch-board, then will the diſtance between this dotted line and the under tip of the ſcroll ſhew the true thickneſs of ſtuff, which is nearly five inches and a half: but there is no occaſion for the thickneſs to come quite to the under ſide; if it comes to the under ſide of the hollow, it will be quite ſufficient, as a little bit glued under the hollow could not be diſcernible, and can be no hurt to the ſcroll, therefore a piece about four inches and a half will do.

FIG. *A* is a ſcroll of a ſmaller ſize, drawn in the ſame manner and with the ſame centres as the others are, but with a centre leſs. The method of finding the raking mould and thickneſs of ſtuff are the ſame as *fig. D*.

Plate 55.

This Shows how a Scroll is to be got out of the Solid .

Fig. A.

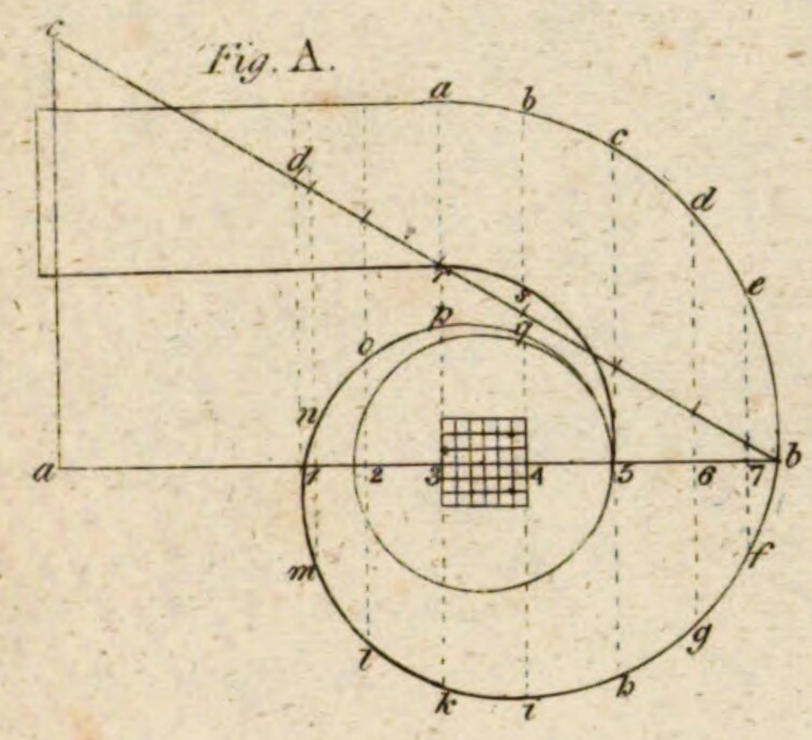
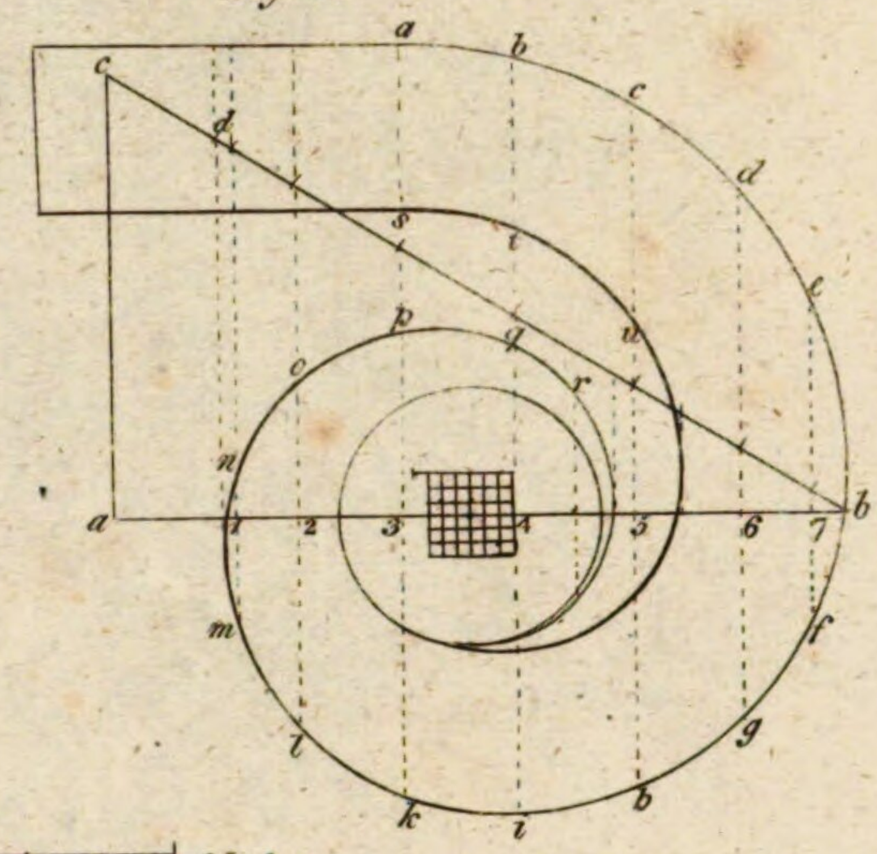
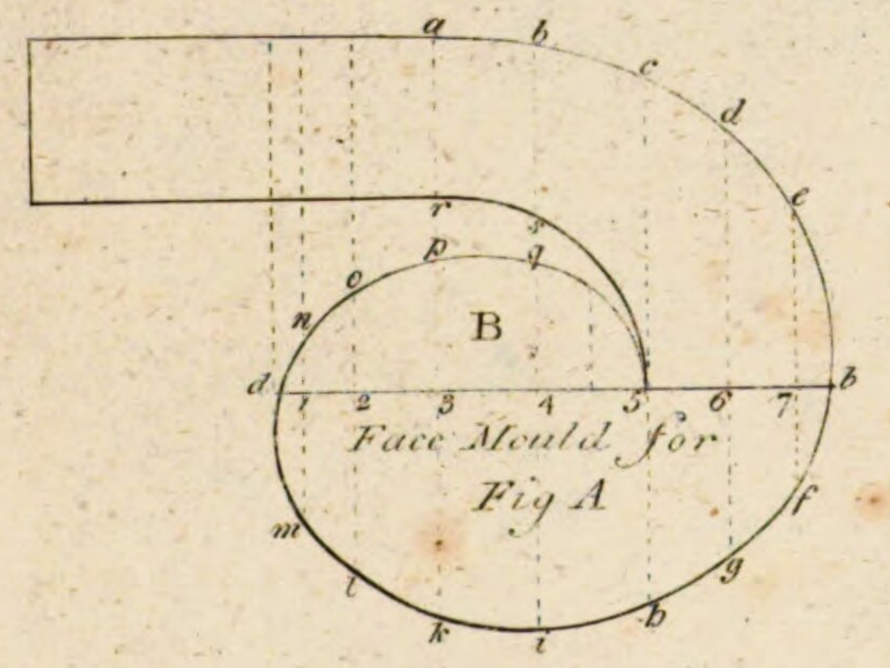


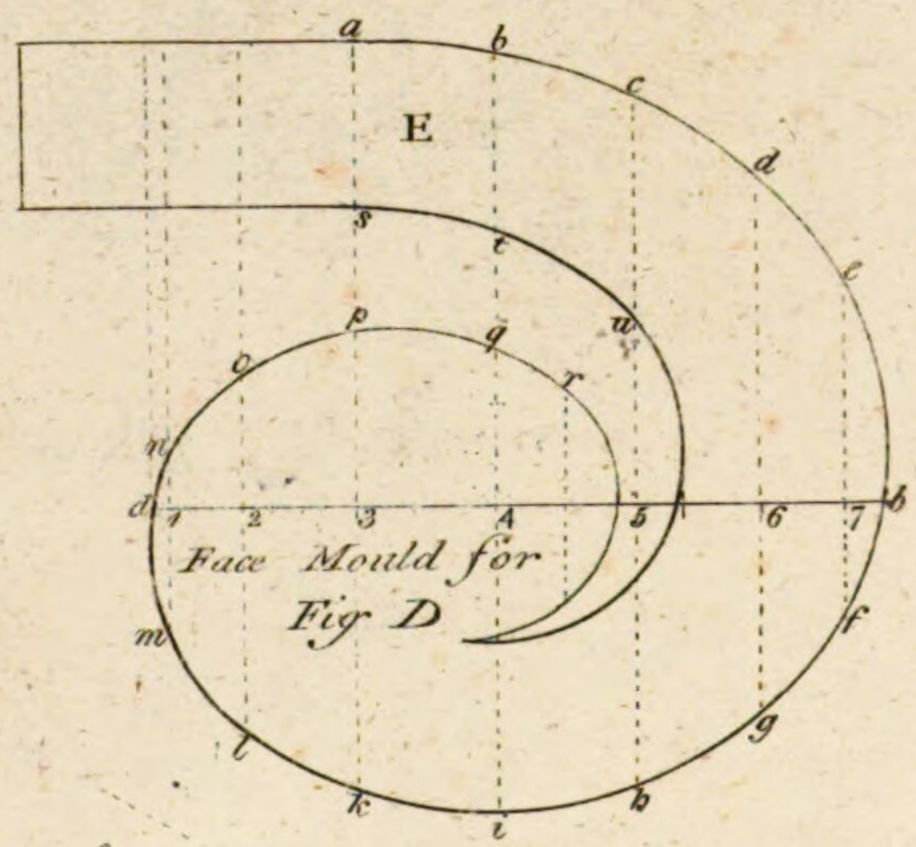
Fig. D.



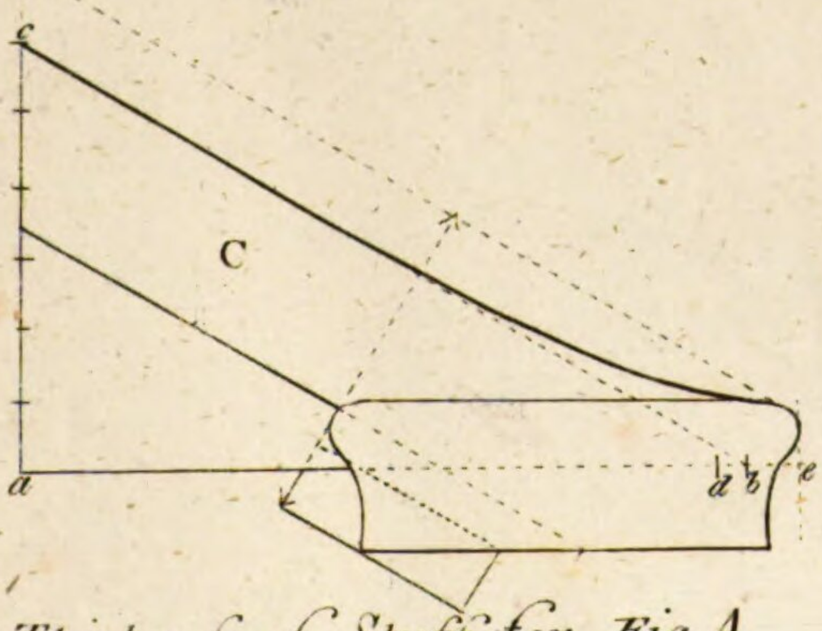
Scale of Inches.



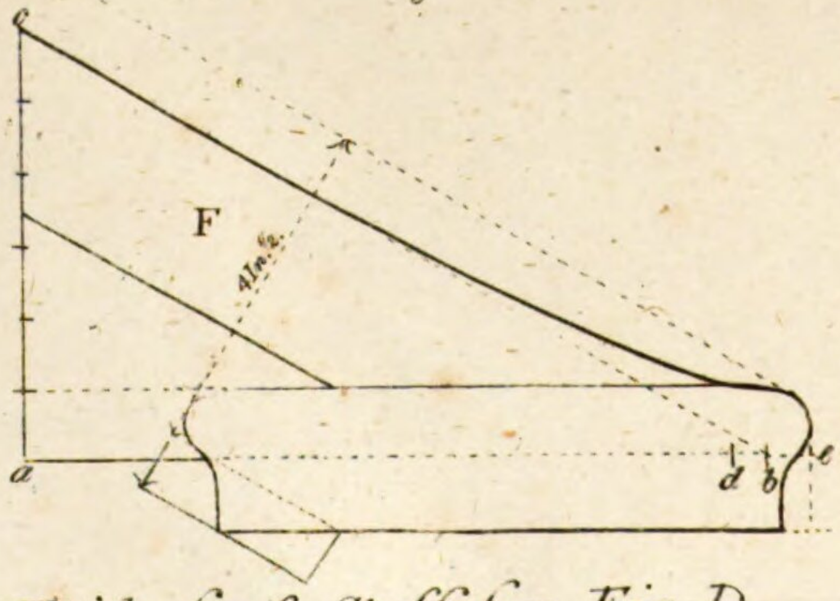
Face Mould for Fig A



Face Mould for Fig D



Thickness of Stuff for Fig A



Thickness of Stuff for Fig D

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Plate 56.

Plan and section of a Stair case with a level.
Landing for its lines see the next Plate.

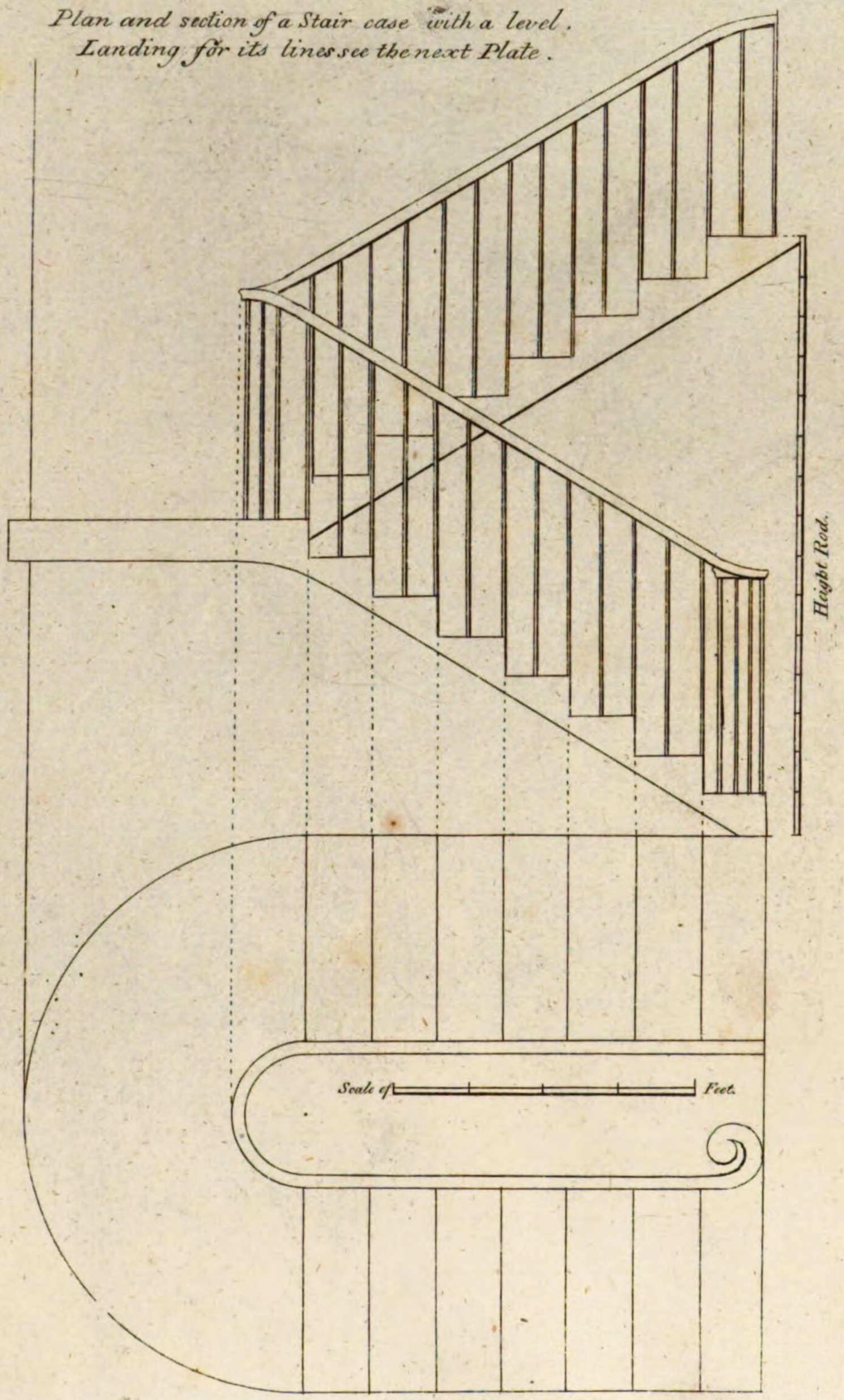

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Plate 57.

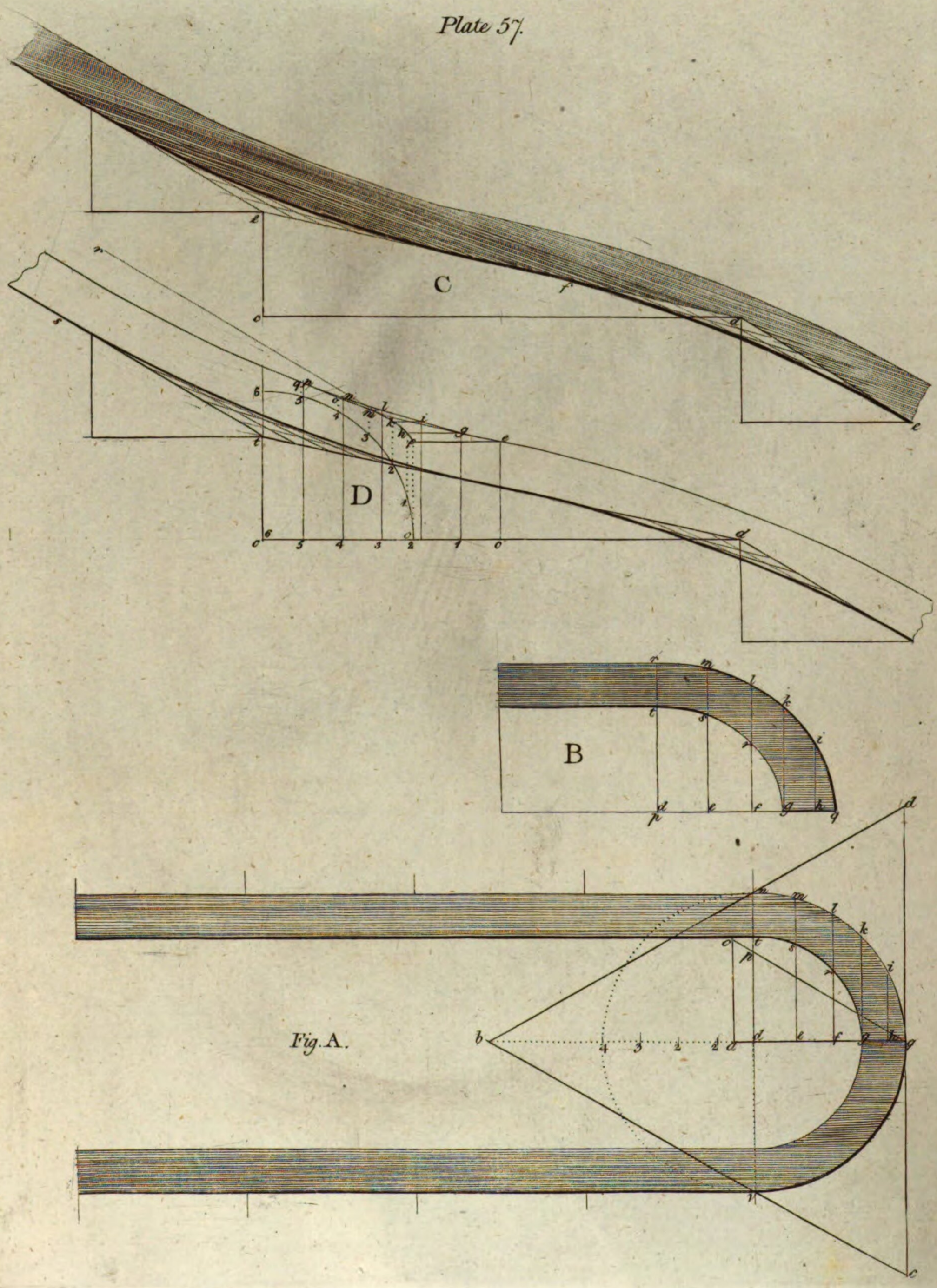


PLATE LVII.

To find the face mould of a ſtair-caſe, ſo that when ſet to its proper rake it will be perpendicular to the plan whereon it ſtands for a level landing, as is ſhewn in the laſt plate.

In *fig. A* draw the central line *b q*, parallel to the ſides of the rail; on the right line *b q*, apply the pitch-board of a common ſtep; from *q* to *a* draw ordinates *n d*, *m e*, *l f*, *k g*, and *i k*, at diſcretion, taking care that one of the lines, as *k g*, touch the inſide of the rail at the point *g*, ſo that you may obtain the ſame point exactly in the face mould; then take the diviſions *q h g f e d*, from *q*, and apply them at *B* from *q h g f e d*; from theſe points draw the ordinates of *B*, and prick them from the plan, as the letters explain; then *B* will be the mould required.

To find the falling mould.

Divide the radius of the circle into four equal parts, and ſet three of theſe parts from 4 to *b*; through *n* and *v*, the extremities of the diameter of the rail, draw *b n* and *b v*, to cut the tangent line at the points *c* and *g*; then will *c d* be the circumference of the rail, which is applied from *c* to *d*, at *C*, as a baſe line; make *c e* the height of a ſtep; draw the hypotenuſe *e d*, at the point *e* and *d*; apply the pitch-board of a common ſtep at each end of their baſes, parallel to *c d*, make *d f* equal to *d e*, if it will admit of it, and by theſe lengths eaſe off the corners by the common method of interſecting lines; then draw a line parallel to it, for the upper edge of the mould.

To find the parallel thickneſs of ſtuff.

The ſame falling mould is again ſhewn diſtinctly at *D*; biſect the line *d c*, at *o*; divide *o c* into any number of parts, as 6; on *c*, as a centre, deſcribe a quarter of a circle to the radius of the rail; divide the arch alſo into ſix equal parts; from the points *c g i l n*, draw the parallel lines *e f*, *g h*, *i k*, *l m*, *n o*; from the equal diviſions in the arch, draw the perpendiculars of 1 *h*, 2 *k*, 3 *m*, 4 *o*, and 5 *q*, to interſect the parallel lines at *f h k m o q*; through the points draw a curve line; draw a right line *r m*, parallel to *ſ t*, to touch the curve; then is the diſtance from *r* to *s* the parallel thickneſs of ſtuff.

PLATE LVIII.

To find a face mould of a rail for a large opening on a level landing.

Let *fig. A* be the plan of the rail; through the centre *C* draw the diameter *s z*, and produce it to A; alſo produce the ſide of the rail out to 2; then take the diameter *z s*, put the foot of your compaſs in *y*, and croſs the line A *z* at A; through A and *y* draw the line *A* 2, cutting the ſide of the rail produced at 2; then the diſtance from *z* to 2 is half the arch line of the rail; take the diſtance *z* 2, and place it on the right line *v v* at *G*, on each ſide of *w*, to *v* and *v*; draw *v* B and *v* C, each perpendicular to the right line *v v*, and equal to the height of a ſtep; make C E and B D parallel to *v v*, each equal to the tread of a ſtep; draw the hypotenuſe *v c*, and the common pitch-boards *v* B D and C E F, at each end; make *v* H equal to *v* D, and C G equal to C F; and eaſe off the angles G C F and D *v* H by the common method of interſecting lines, which will give the curve of the under edge of the falling mould; draw a line parallel to it, equal to the thickneſs of the rail, will give the upper edge; produce the line *v v* out to *y*, from the middle *w* of the line *v v*, at *G*; make *w y* equal to *w y* at the plan *fig. D*; *y* being the place of the joint upon the plan, draw the line *y* 2 1 perpendicular to *v v*, cutting the upper ſide of the falling mould at 2, and the under ſide at 1; from 1 draw the line 1 6, parallel to *v v*, cutting the line 8 *w*, produced to 6; draw a tangent line M L; parallel to the chord *a b*, at the plan *B*, to the chord *a b* draw any number of indefinite perpendiculars, obſerving to draw a perpendicular through every joint, as from the joint *a q* and *b y*; then take the diſtance 1 2 from your falling mould at *G*, and ſet it from M to O of the plan at *B*; alſo from *L* make L N O equal to 6 7 8 at *G*; then the ſhaded parts at N O and M O are ſections of the rail; then draw a line *o b*, to touch the corners of the ſections at *o* and *b*; at the points *o*, *a*, *d*, *e*, *f*, *g*, *h*, *b*, and *p*, draw perpendiculars to *o b*; then *C* being pricked from the plan at *B*, as the letters direct, will be the true face mould.

FIG. *D* is a plan of the ſame ſize, ſhewing the face mould at *F*, when ſprung, which will be a very great ſaving of ſtuff; and not much more trouble in laying it down when properly underſtood. This method will be clearly explained in the following pages.

Plate 58

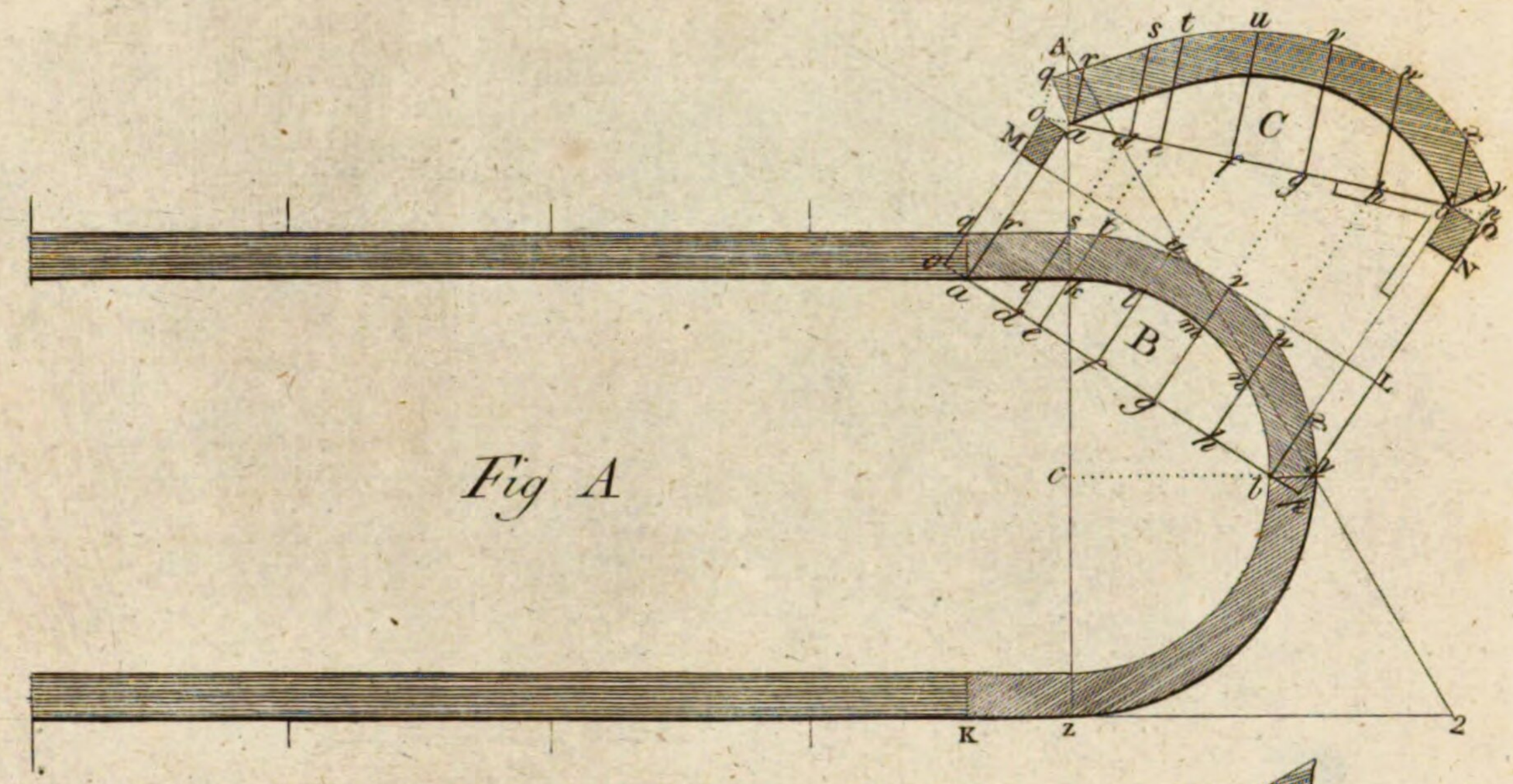


Fig A

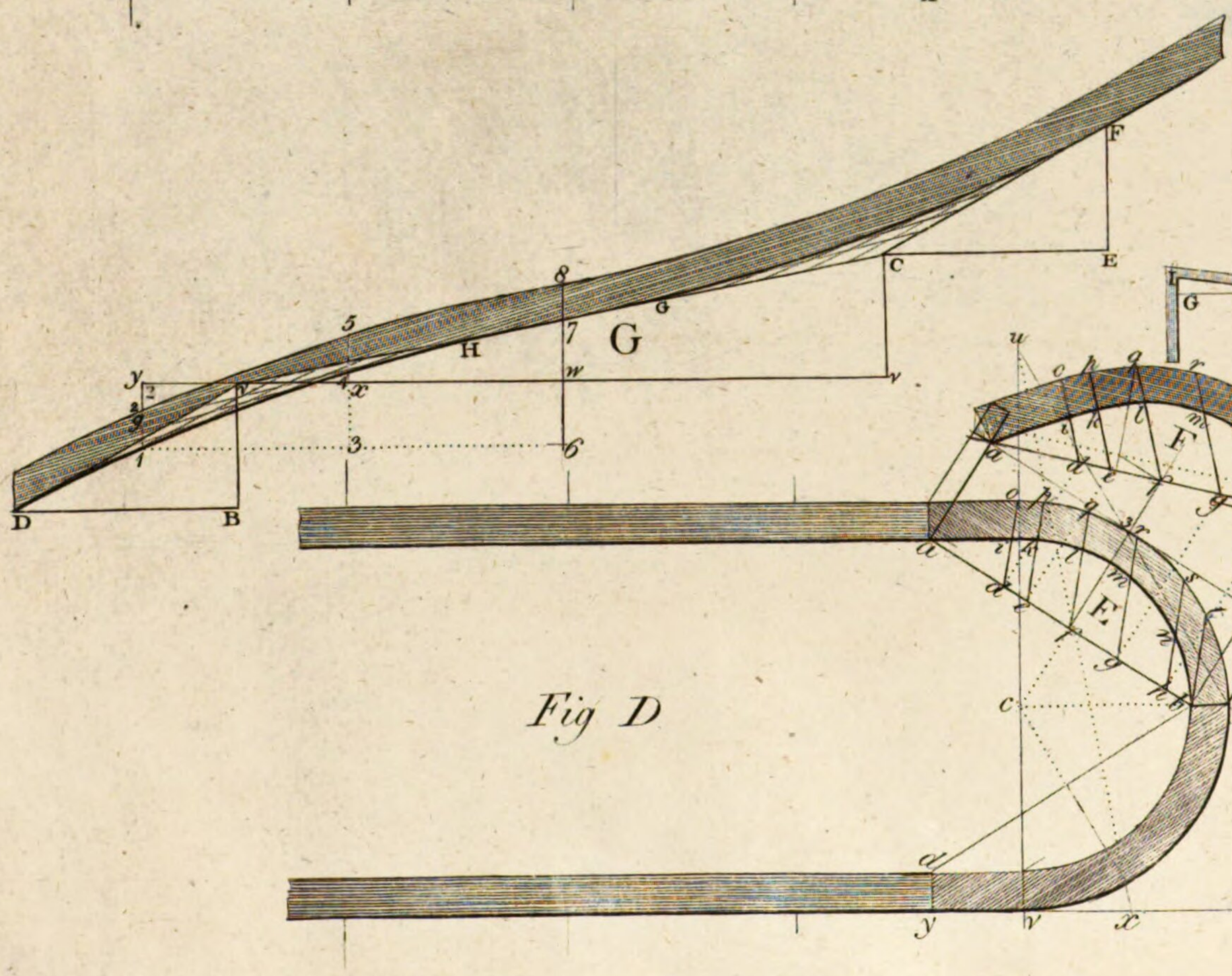


Fig D

Plate 59.

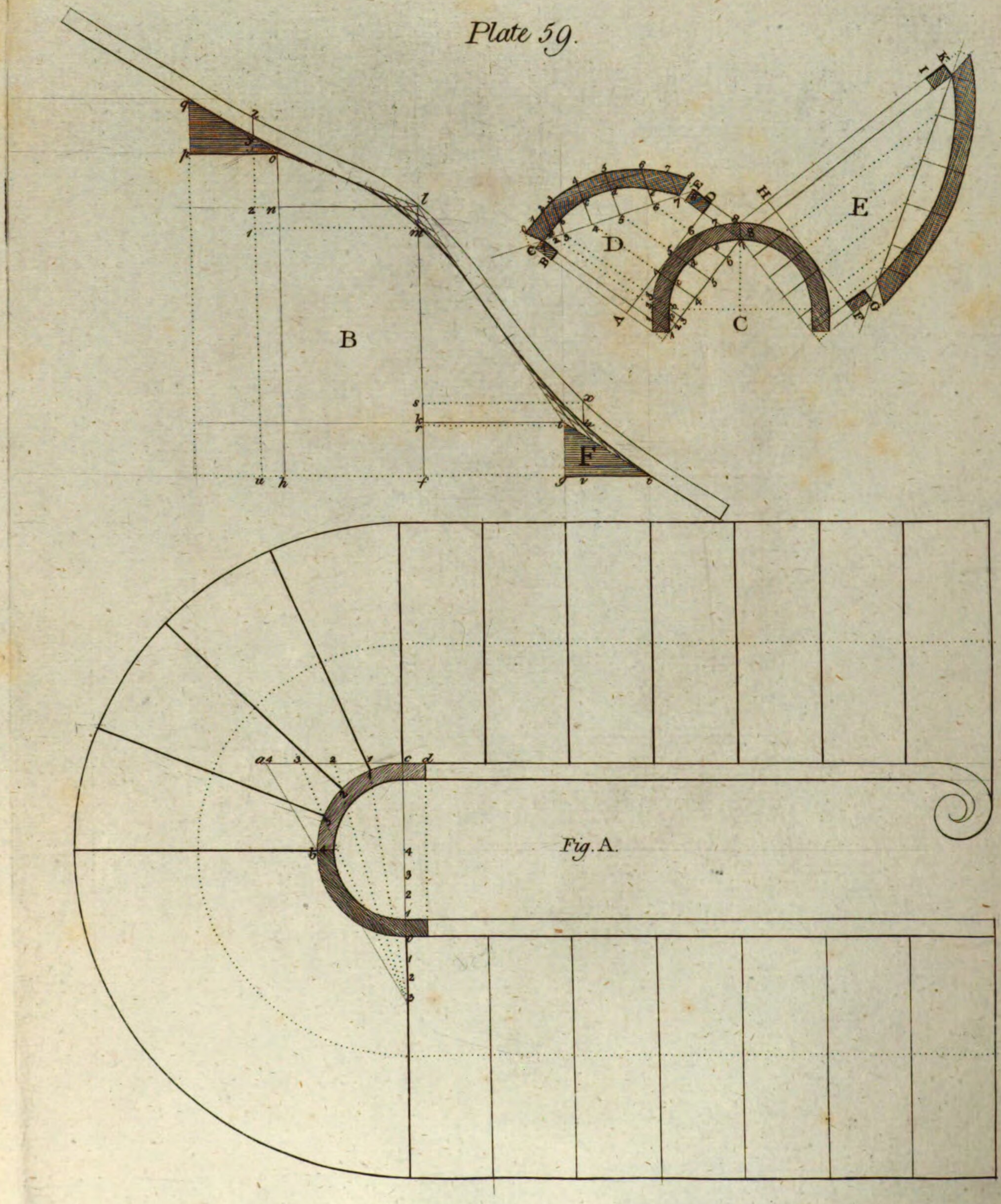
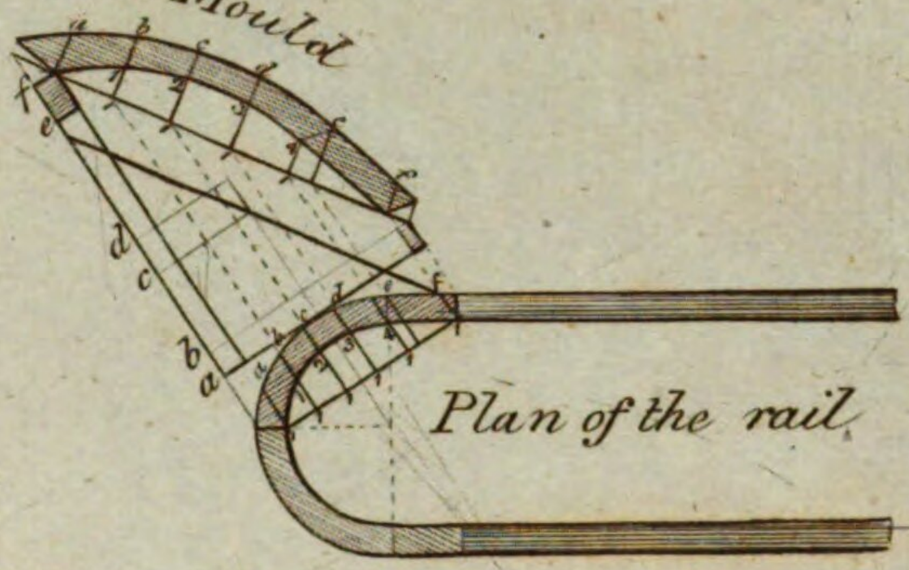


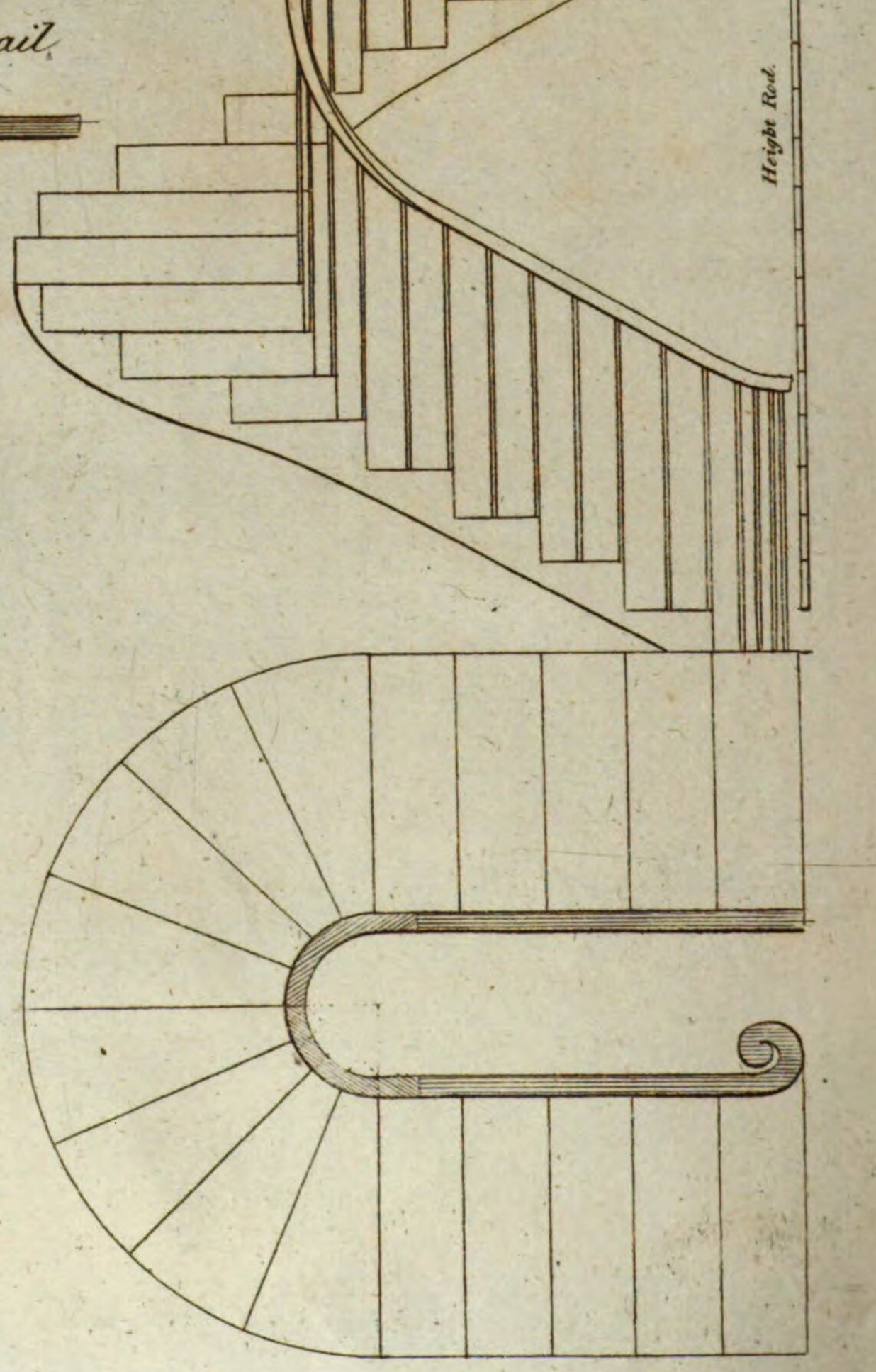
Fig. A.

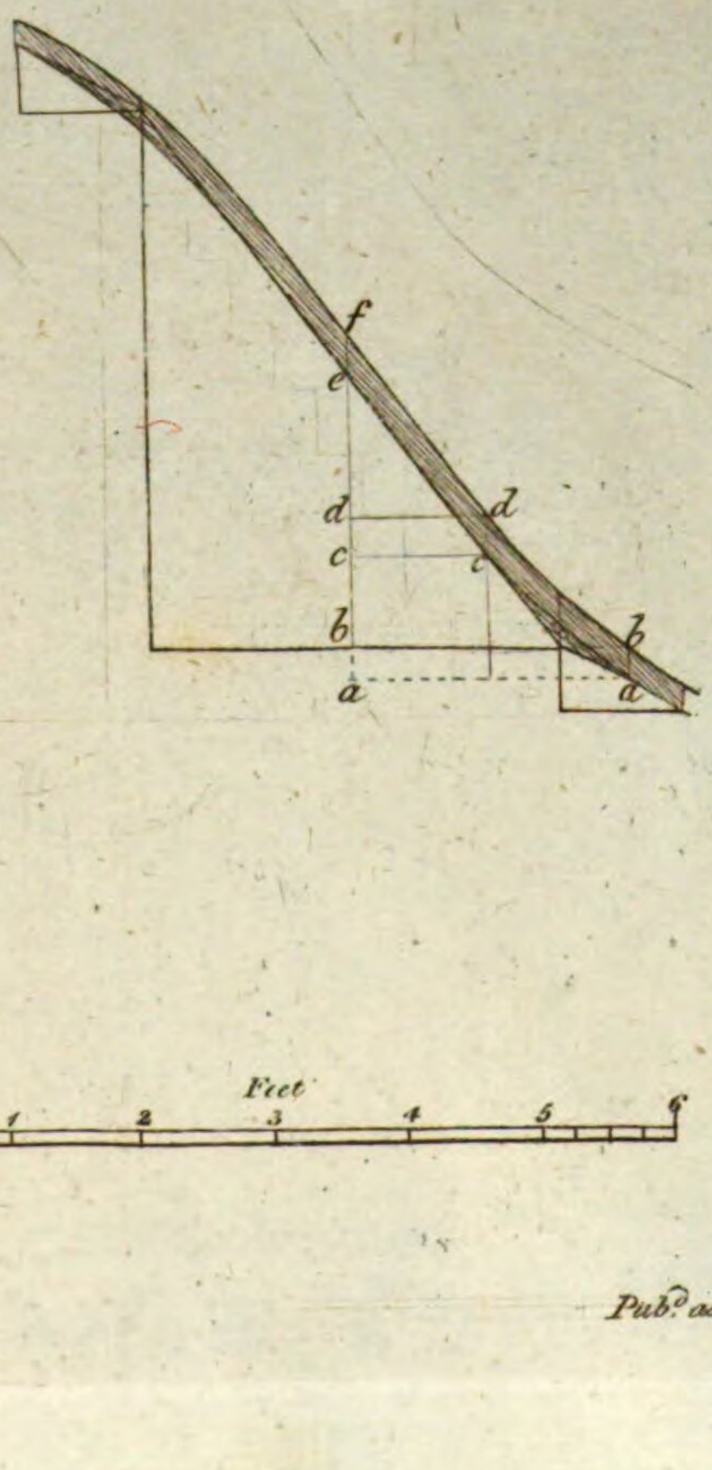
Plate 60.

Face Mould



Plan of the rail.





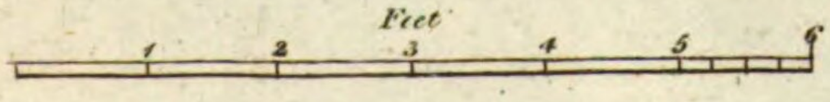


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PLATE LIX.

To draw the falling mould of a rail having a quarter ſpace in it; thence to find the face moulds of the circular part.

At the plan *fig. A*, *a c* is the ſtretch out of half the circular part of the rail, found by the ſame method as in the foregoing plates; or it may be found more exactly thus: Divide the radius into four equal parts, and ſet three of the diviſions out to 3, and draw a line from 3 to *b*, cutting the ſide of the rail produced at *a* *; from the point *f* in the right line *h g* at *B*, make *f h*, and *f g*, each equal to the ſtretch out of half the rail, that is, equal to *a c*, *fig. A*; draw the perpendiculars *h o*, *f l*, and *g t*; at *B* apply the pitch-board of a common ſtep at *F*; through the point *t*, draw *t k*, parallel to *g h*, cutting the line *f l*, at *k*; from *k* to *l* ſet up the height of the four winders; through *l* draw *l n*, parallel to *g h*, cutting the line *h o*, at *n*; from *n* make *n o*, equal to the height of a ſtep, for the quarter ſpace upon the landing which only riſes one ſtep; draw the hypotenuſe *l o*; again, draw *o p* parallel to *g h*, and *p q*; perpendicular to *o p*, draw *q o*; then *o p q* is the pitch-board of another common ſtep above the winders; then theſe angles being eaſed off by the method of interſecting lines, the falling mould will be completed, as in the laſt plate; make *f u* and *f v*, from *f*, equal to *a d*, *fig. A*, that is, the ſtretch out from the middle of the arch at *b*, to the joint; draw *v x*, and *u z* parallel to *f l*; then take the heights from I to *y* and *z*, and ſet them from A to B and C, will give the ſection B C; then take *m l* from the falling mould, and from D make D E equal to it, will give the ſection D E; then take *w x* from *B*, and make F G, at *E*, equal to it; from *w*, draw *w r*, parallel to *g h*, cutting *f m* at *r*; from *r* take the heights from *m* and *l*, and ſet up theſe heights from H, to I and K at *E*, it will give the ſection I K; then the face moulds upon *D* and *E* will be traced as directed in the laſt plate.

* The line *a c* is nearly equal to the ſemicircumference, and is the moſt exact of any that ever has yet been ſhewn by a geometrical method; it may be depended on in practice; it is abſolutely impoſſible to find a right line exactly equal to the circumference of a circle; this has exerciſed the attention of the greateſt mathematicians in every age.

PLATE LX. wants no explanation.

PLATE LXI.

To draw a falling mould for a rail having a winder all round the circular part, as is ſhewn in the laſt plate, thence to find the face mould.

To deſcribe every particular in this, would almoſt be repeating what has been already deſcribed in the laſt plate; the heights are marked the ſame upon the falling mould at *D*, as they are at the face mould, which will give the heights of the ſections of the rail; and the face mould at *C*, is traced from the plan *B*, according to the letters; In plate 60 is ſhewn the ſame thing, only with this difference, that the face mould is partly ſtraight at one end, becauſe the joint muſt have been weaker, had it been made where the circular part of the rail begins, as is ſhewn in this plate; but the method of tracing this is nothing different from the other in the laſt plate: Only I would have the reader to obſerve, in plate 60, that ordinates are drawn through the places where the circular part begins, which will give the ſame points on the face mould; for, by this means, you will be able to determine what part of the face mould is exactly ſtraight, and where the crooked place of your mould begins. I hope the reader will underſtand the ſame thing in the following plates, without being told a ſecond time. *G* ſhews the application of the mould to the plank; take the bevel at *H*, and apply it to the edge of the plank at *D*, and draw the line *b c*; then apply your mould to the top of the plank, keeping one corner of it to the point *B*, and the other corner cloſe to the ſame edge of the plank; then draw the top face of the plank by your mould; then take your mould, and apply it to the under ſide at *c*, in the ſame manner.

Plate. 61

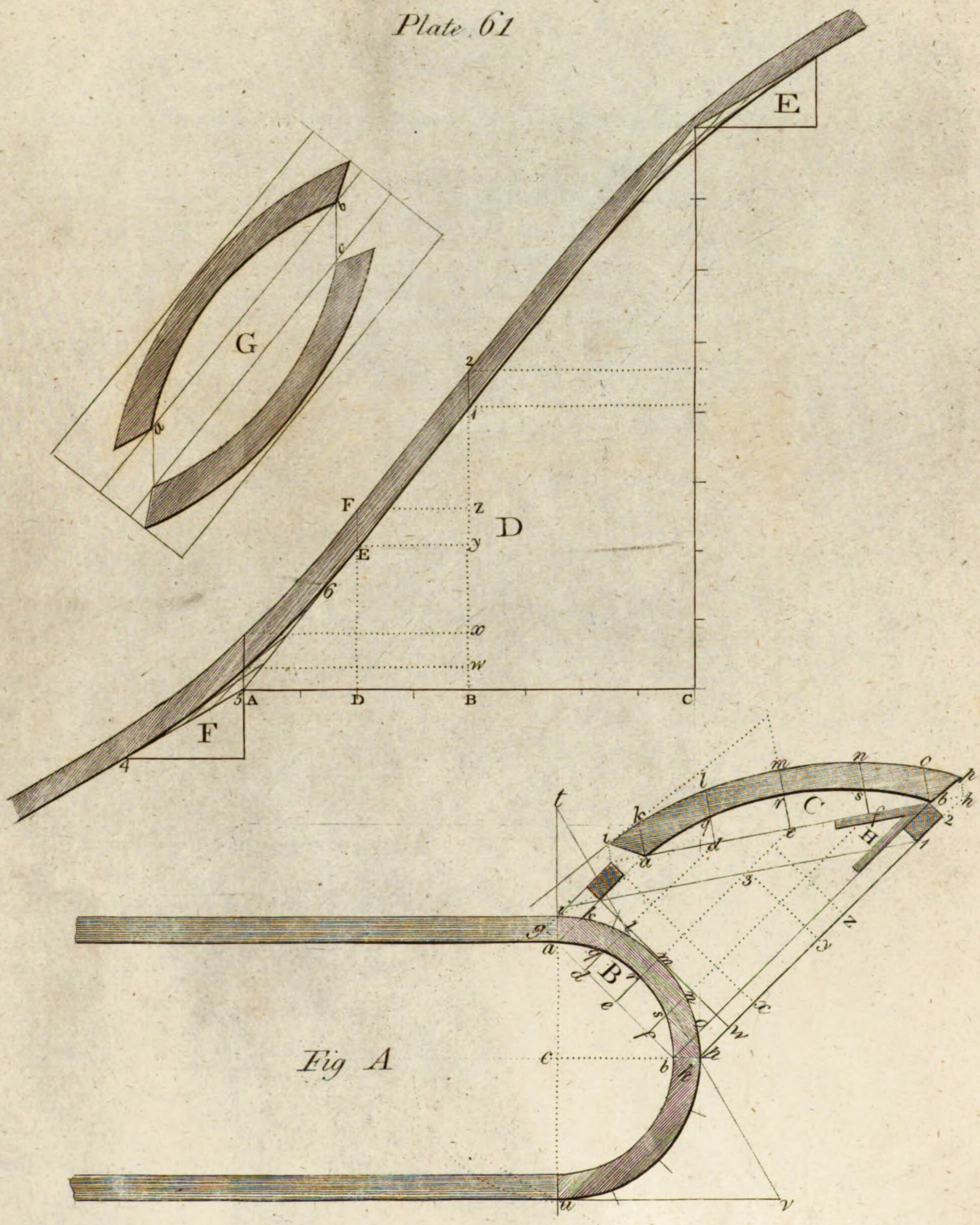

Plate 62.

An eliptical Plan & section of a stair case. For its lines see the next Plate

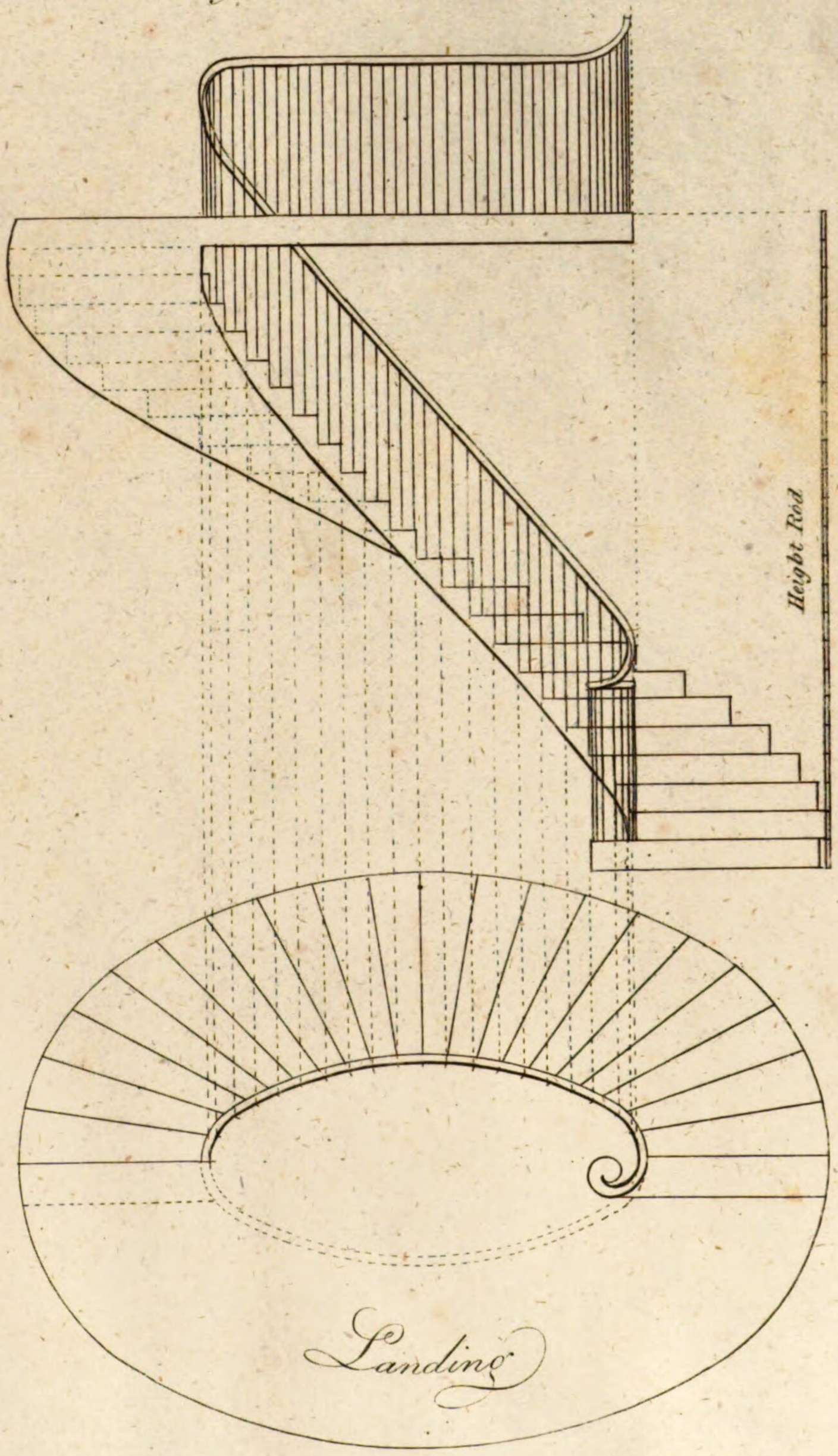

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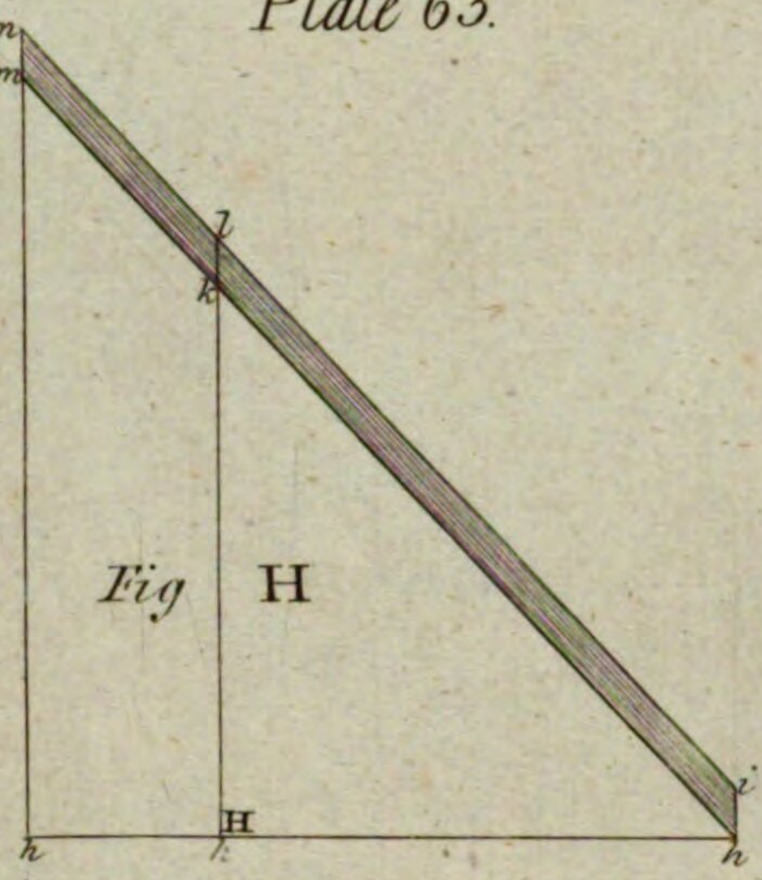
Plate 63.



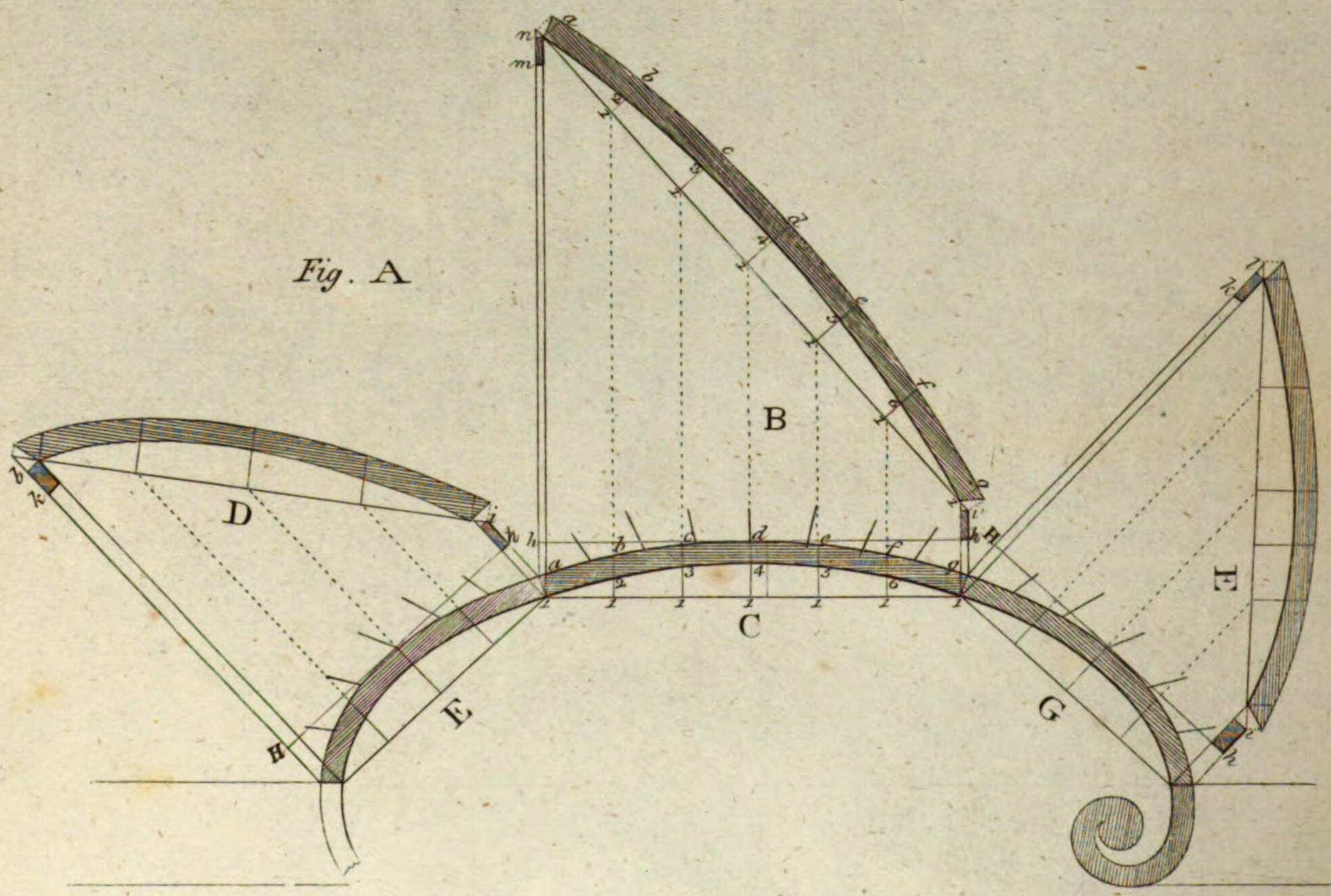


PLATE LXIII.

How to draw the face moulds of an elliptic ſtair.

The plan and ſection being laid down as in plate 62, the reader will obſerve, that the ends of the ſteps are equally divided at each end; that is, they are equally divided round the elliptic wall, and alſo at the rail. In this plate, the rail is laid down to a larger ſize than that in the laſt plate; the plan of this rail muſt be divided round, into as many equal parts as there are ſteps; then take the treads of as many ſteps as you pleaſe, ſuppoſe 8, and let *h h*, at *fig. H*, be the tread of 8 ſteps from *H*; on the perpendicular *h m*, ſet up theheight of as many ſteps, that is, 8; and draw the hypotenuſe *m h*, which will give the under edge of the falling mould. The reader will obſerve, that this falling mould will be a ſtraight line, excepting a little turn at the landing and at the ſcroll, where the rail muſt have a little bend at theſe places, in order to bring it level to the landing and to the ſcroll; then mark the plan of your rail in as many places as you would have pieces in your rail (in this plan are three); then draw a chord line for each piece to the joints; alſo draw lines parallel to the chords, to touch the convex ſide of the plan of the rail; from every joint draw perpendiculars to their reſpective chords. Now the tread of the middle piece at *C* being juſt 8 ſteps, the height of the ſection from *h* to *m* is 8 ſteps; and the ſection *m n* is the ſame as *m n* on the falling mould, and the ſection *h i* is the ſame height as *h i* upon the falling mould; then draw a line to touch the ſections, and complete your face mould as in the foregoing plates, each of the other pieces at *F* and *G*, the treads, being ſix ſteps; therefore, from your falling mould ſet the ſtretch of 6 ſteps; from *h* to H draw H *l*, parallel to *h n*, then H *k l* will give the heights of the ſections at *D* and *E*; every thing elſe agreeable to the letters.

Note. By the ſtretch out of 8 ſteps, or any other number, is not reckoned on the chord; but it is the ſtretch out round the convex ſide of the rail, or what ſome people call the inſide.

PLATE LXIV.

The tread of a winding ſtair being given, round the middle and the plan of the rail; to diminiſh the ends of the ſteps at the rail, ſo that the balliſters ſhall be all regular, or of an equal height, when finiſhed.

Let the firſt winder begin about the firſt ſtep before the circle of the rail, at *D*; from *a* to *e*, in the plan *fig A*, is the ſtretch out of half the circular part of the rail; the method of finding it has already been explained in the foregoing plates; from *e* draw *e* H, perpendicular to the ſide of the rail; by reckoning round the dotted line, from 5 to 10, you will find there are five treads, or five winders; therefore from *q* to 5 ſet up the height of 5 ſteps; produce the longeſt ſide *a b* of the pitch-board *D*, to *c*; biſect *b c*, at 2; draw a line from 2 to 5; then divide 2 *b* and 2 5, each into the ſame number of equal parts; and interſect the angle by the common method of interſecting lines, will give the under edge of the falling mould; then a line being drawn parallel to it, to the thickneſs of the rail, will give the upper edge, which is the falling mould for half the rail; draw the lines 1 *l*, 2 *k*, 3 *i*, and 4 *h*, parallel to 6 *g*, to interſect the falling mould at the points *h*, *i*, *k*, *l*; from theſe points draw the parallel dotted lines to *q* H, down to the rail at *ſ t v u*; from *c* draw *c s*, *c t*, *c v*, and *c u*, cutting the arch line of the rail *m*, *n*, *o*, *p*, will give the ends of the ſteps at the rail; then draw lines from *m*, *n*, *o*, *p*, through 6, 7, 8, 9, will be the plan of the ſteps.

To find the face mould of a rail, ſo that it may be got out of the leaſt thickneſs of ſtuff poſſible.

Lay down the plan of the rail at any convenient place, as No. 3; draw the chords of the rail N O and O P, from the centre K draw K E, perpendicular to the chord N O, cutting the outſide of the rail at C; in the ſame manner draw the chord *w x*, at the plan, *fig. A*; from the centre *g*, draw *g f* perpendicular to it, cutting the outſide of the rail at *f*; from *c* draw a line *c f*, to cut the tangent line at *v*; draw a line *v* E, parallel to *q* H; from the joint of the rail at *h* draw *h* B, alſo parallel to *q* H, interſecting the under ſide of the rail at A, and the top ſide at B; draw from A a line A F parallel *b q* from *F*, at No. 3; make F G H equal to F G H, at No. 1; from *C*, at No. 3, make C D E equal to C D E, at No. 1; and make *A B*, at No. 3, from *A*, equal to *A B*, at No. 1; draw a line *B R*, for the chord of the mould to touch the ſhaded ſections, perpendicular to N O and A F; from *E* draw E M, perpendicular to B R; make *c i*, at No. 2, equal to 1 C, at No. 3; make *i e* perpendicular to *c i*, equal to E L, at No. 3; make L M equal to *c e*, at No. 2; from E draw E T, parallel to A F, cutting the chord line B R at T; from the points T and M, draw the line T M, then T M will be one of the ordinates; all the other ordinates are drawn at diſcretion, parallel to it, and completed in the ſame manner as is ſhewn in plate 9, for the ſections of a cylinder.

The reader will take notice, before the face mould at No. 3 can be applied, the edge of the plank muſt be firſt bevelled according to No. 2; then the plumb-line will be drawn on the bevelled edge of the plank, by the bevel that is drawn at No. 3.

Note. By this method of proceeding, a three inch plank will almoſt be ſufficient for any rail of this kind however it ramp; whereas in many caſes, by the common method, it may require a plank five or ſix inches thick. Many other advantages will attend the manner of ſetting out this plan; I ſhall mention one or two: in fixing the banniſters, they will be all regular, and the ſtring board will be as eaſy as the rail itſelf; the ſkirting will alſo be quite regular, for the ends of the ſteps are wider and wider as they go round to the middle of the ſemicircle; laſtly, a blackſmith may put up an iron rail with very little trouble, the banniſters being all regular; whereas no other plan will admit of it, unleſs it is ſet out in this manner.

Plate 64.

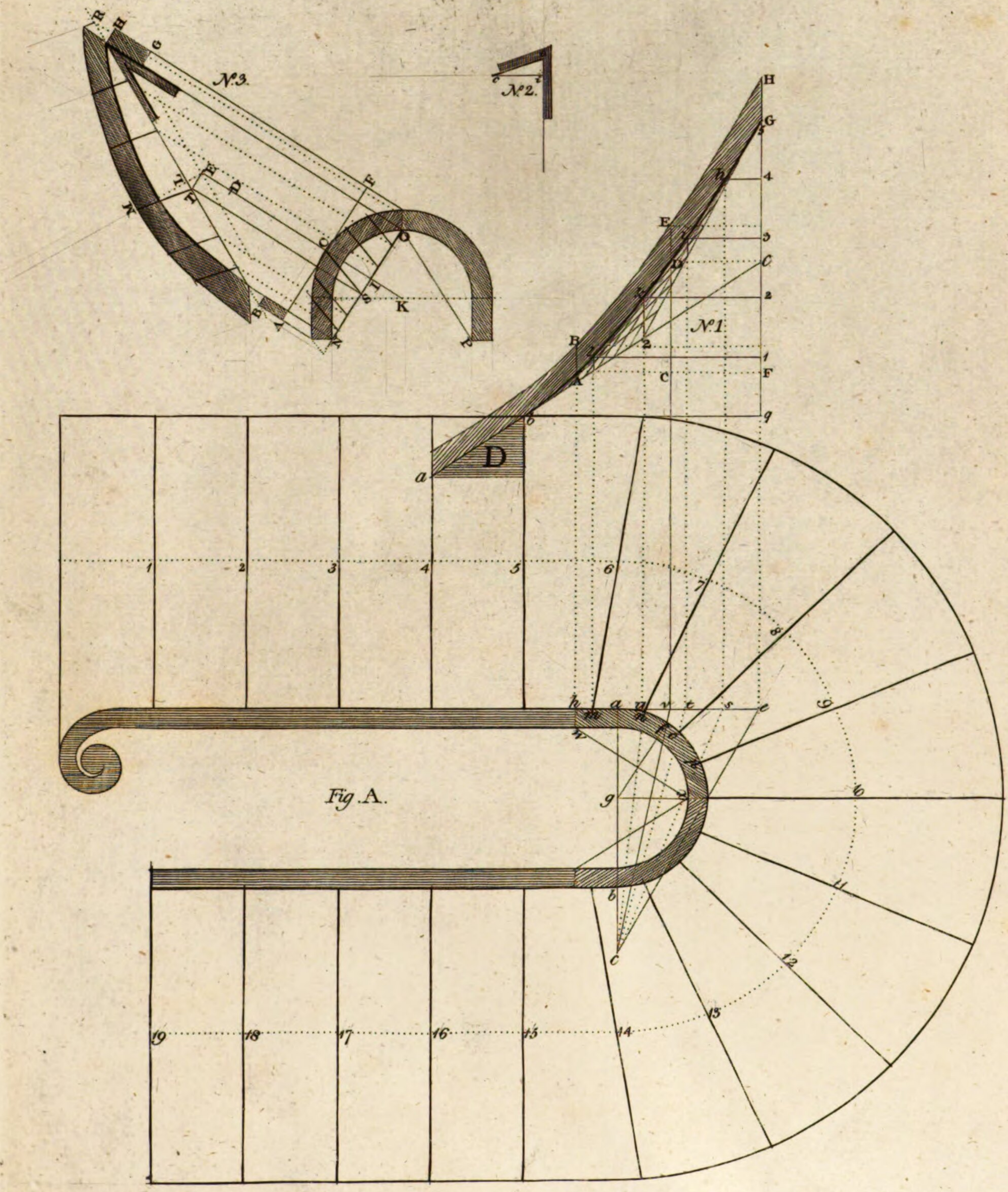


Plate 65.

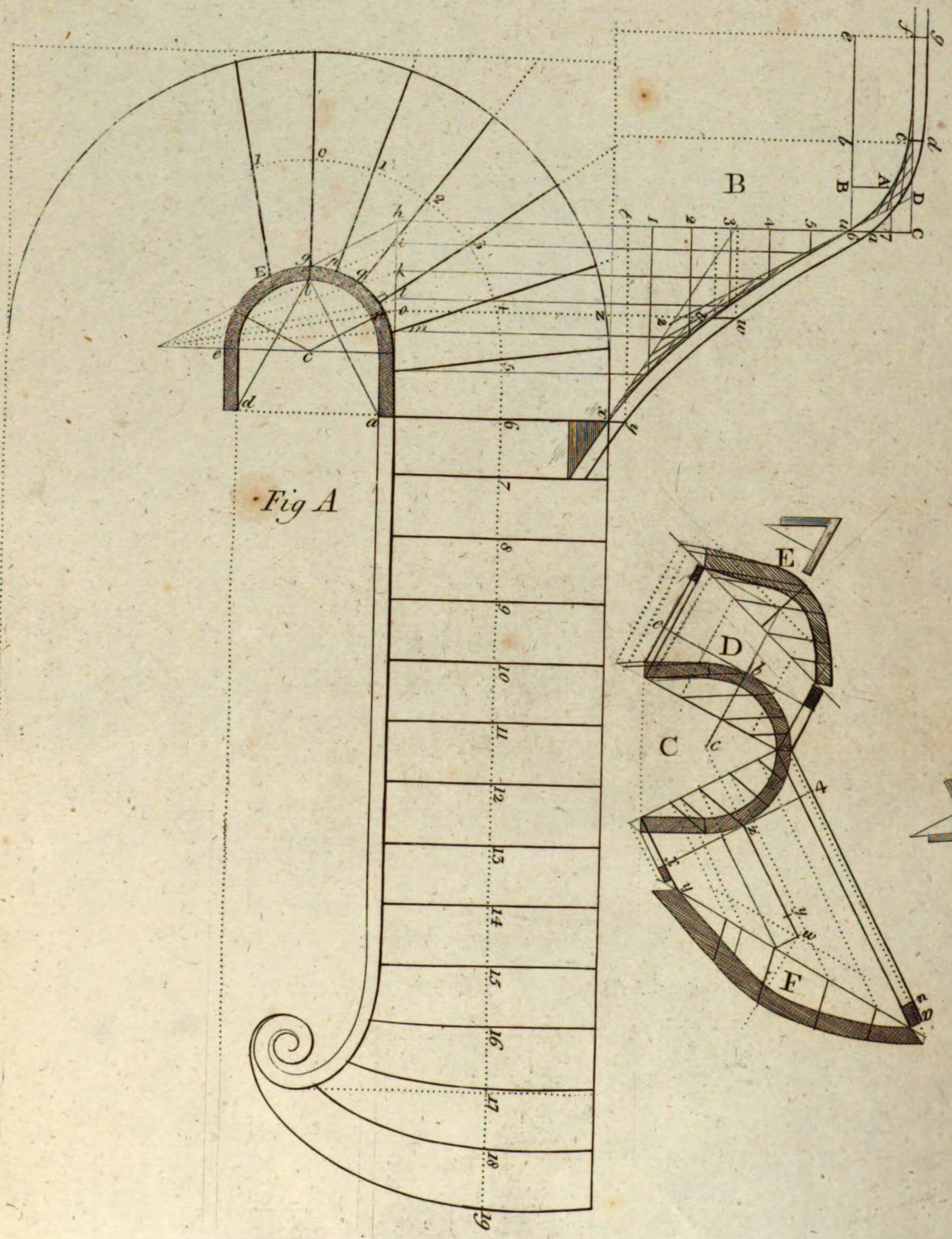


Fig A

PLATE LXV.

To diminiſh the ſtep of a ſtair winding round one of the quarters to a level landing.

Find the ſtretch out round half the circular part of the rail, as directed for the foregoing plates, and complete the falling mould as directed in the laſt plate, for the winding part of the rail, which is ſix ſteps from *t* to *w*; in order to bring the rail with an eaſy turn round to the landing, ſet off the height of another ſtep from *x* to 7, and let the under edge of the rail be half the height of a ſtep above that to C; or it may be more, according to the diſcretion of the workman; then the rail will be half the height of a ſtep more upon the landing than it is upon the winders; through C draw C *f*, parallel to the baſe, and continue the line 2 *u*, that forms the interſection below for the winders up to D, and eaſe off the angle *u* D *c* by interſecting lines, will give the under edge of the mould turning up to the landing: in order that the laſt ſtep beyond the quarter ſhould alſo follow the mould, draw a line through 7, the height of the laſt ſtep, parallel to *u b*, or C *c*, cutting the under ſide of the falling mould at A; through A draw A B, parallel to C *t*; then *u B* is the tread of the laſt ſtep at the rail, which is ſet from *g* to E. The face moulds at *D* and *F* are completed in the ſame manner as directed in the laſt plate, and the mould in plate 58, at *fig. D*, is alſo laid down by the ſame method, the height of the ſections being taken from the falling mould that correſponds to that place of the rail which the face mould is made for; and the bevels that are laid down above each face mould will ſhew how much you muſt bevel the edge of your plank, before you can apply the face moulds to the plank; then draw the plumb of your rail, upon the bevelled edge, by the other bevels that are ſhewn at the ſections; then apply your mould to each ſide of the plank, keeping it fair with the bevelled edge, the ſame as in other caſes before mentioned.

PLATE LXVI.

This plate ſhews the method of capping an iron rail, upon much the ſame principles as the others, but with leſs trouble.

How to find the thickneſs of ſtuff for capping of an iron rail.

Lay a thin broad piece of wood, as *b*, upon the top of the iron, upon the place that is to be capped, and turn it round upon the iron, till you ſee the greateſt ſpace between the iron and wood to be as little as poſſible; then the open ſpace will ſhew what thickneſs muſt be added to the thickneſs of the rail.

How to find the plumb of the piece, for the application of your mould.

After having found what thickneſs of ſtuff will do, apply the ſolid piece itſelf, *b*, to its place, then let one of the ends, as *d e*, be cut plumb.

How to trace the under ſide of the plank to the iron, inſtead of the face mould.

Make a pricker, as *c*, with a ſteel point in the upper end, and let it be notched out, ſo that when it is applied on each ſide of the balliſter, it may juſt leave the thickneſs of the rail between each point; then take your pricker *c*, and prick your piece *b*, at every balliſter; always keeping your pricker cloſe to every balliſter. This being done both outſide and inſide, if you inſpect *C*, it will make it plain, where you ſee the ſides of the plank flatted out, which ſhews upon the under ſide at the black dots; ſtrike a plumb-line *d e*, upon the end of your plank *b*, and this plumb-line will ſhew how the top is to be pricked off from the bottom, which you ſee at *C*; the under ſide is ſquared over to the edge, from your pricked points, and from thence drawn acroſs the edge to the rake, which is formed by the plumb upon the edge, then ſquared over the top ſide, and then it is to be pricked off from a line drawn from the point *d*, in the end ſection *D*, which the plumb-line gives upon the end, along the top face of the plank, parallel to the edge, and not from the ſquare edge of the plank.

Plate 66.

This Plate shows the method of caping an iron rail

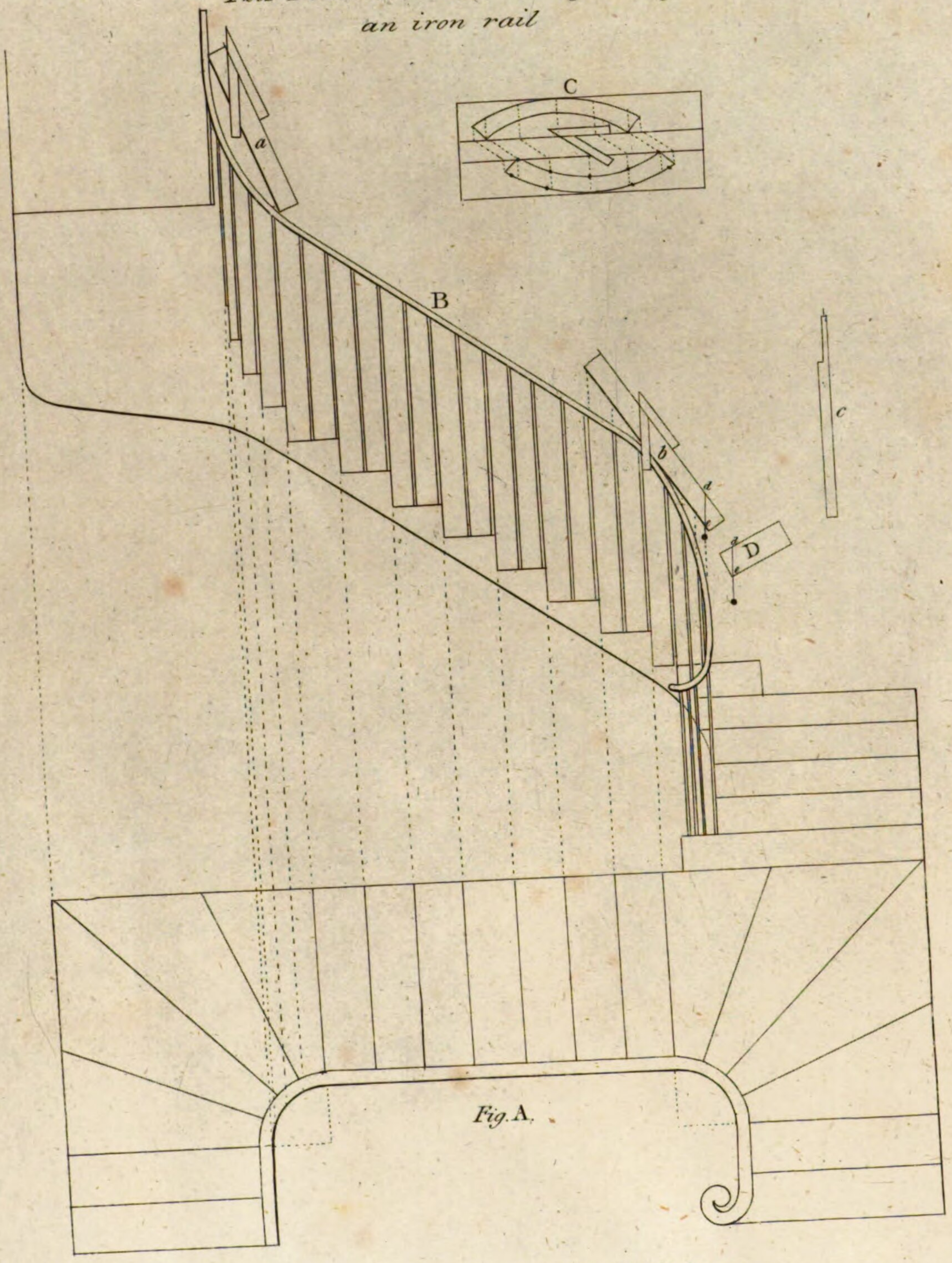


Fig. A.

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Plate 67.

This Shows how to glue a Rail in Thickness.

Fig E.

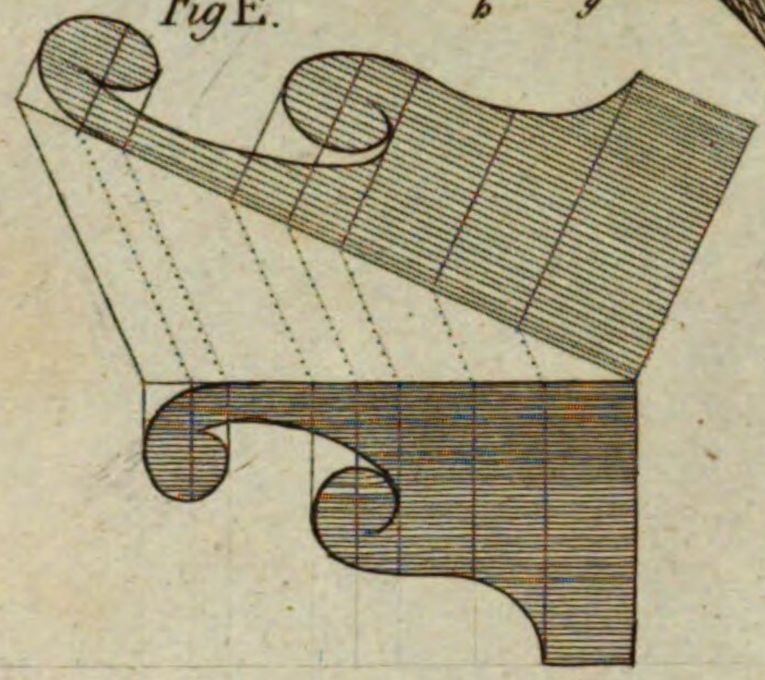
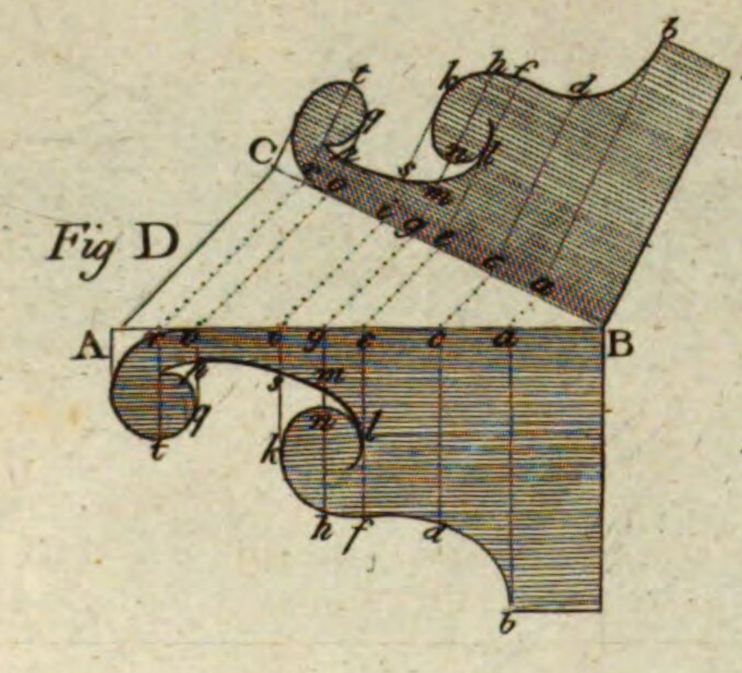


Fig D



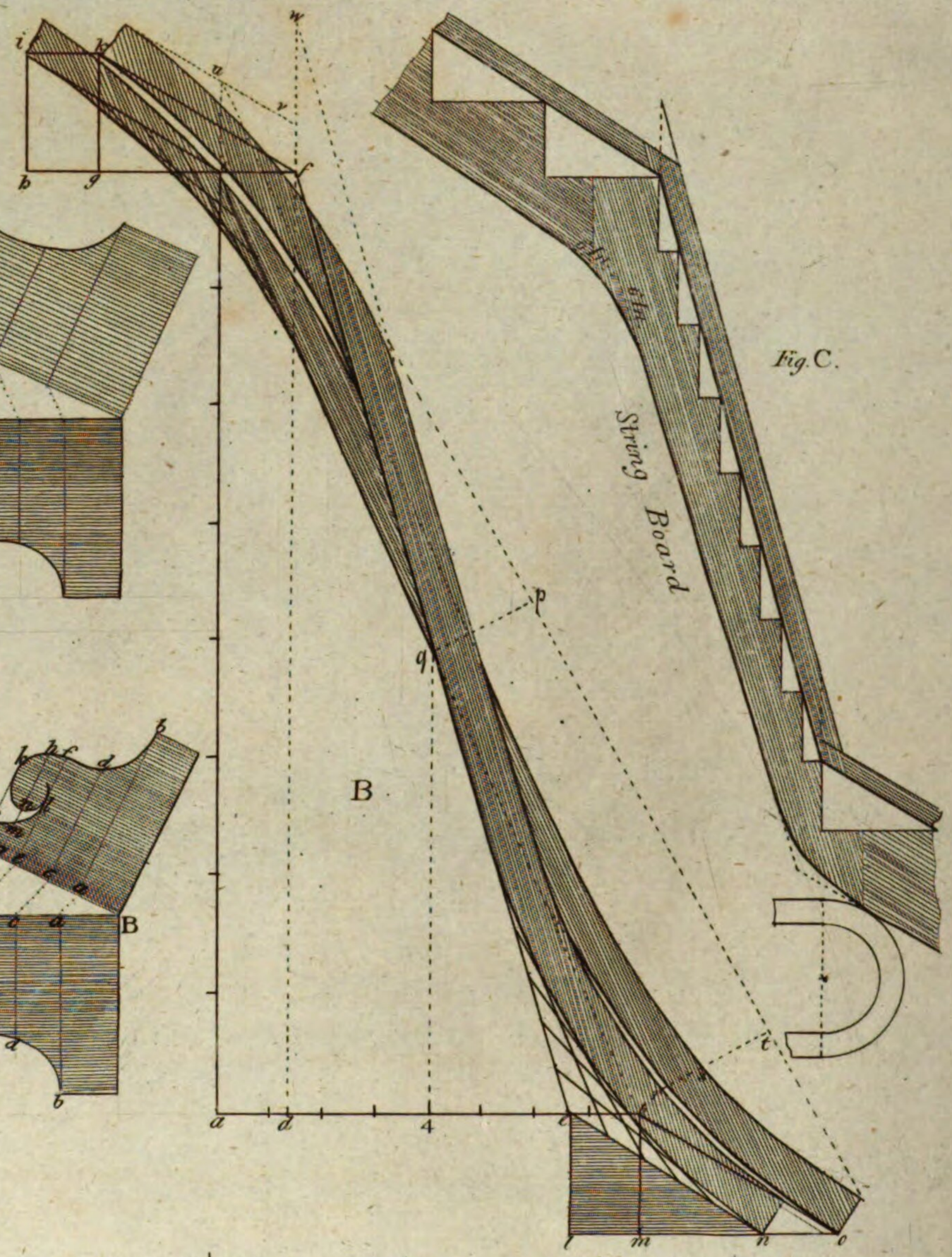


Fig C.

Fig. A.

Scale of Feet.

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PLATE LXVII.

This plate ſhews the method of gluing a rail in thickneſſes; but if I muſt give my opinion, a rail got out of the ſolid is much more preferable, although you are obliged to have more end joints in it; but if your joints are well ſcrewed together, a ſolid rail has a more beautiful appearance than a rail glued up, having ſo many different thickneſſes of glue, which makes it have a black and naſty look with it; if a perſon is ever ſo careful, the joints will ſtill ſhew, and this rail in itſelf having a natural tendency to ſpring, the leaſt dampneſs will make it give way in time; but as this is held by ſome a very valuable acquiſition, I ſhall proceed to lay down the moulds for it.

To ſhew the application of the outſide and inſide falling moulds to the upper and under faces of the plank, to give it the form of the twiſt.

A b is the ſtretch out of the greateſt circle in *B*, and *a c* the height of the ſteps; again, *d e* is the compaſs of the leſſer circle, ſet in the middle between *a b* and *d f*, the height of the ſteps, the ſame with *a c:* therefore the triangle *a b c* is the pitch-board of the inſide falling mould; and *b m o* at the bottom, and *i h c* at the top, are the pitch-boards of two common ſteps; which lines, when interſected, will give the under line of the inſide falling mould. In the ſame manner *d f e*, with the two common ſteps *k g f* at the top, and *e l n* at the bottom, will give the under line of the outſide falling mould. The top lines are only drawn parallel to the under lines to the thickneſs of the rail.

How to apply theſe moulds to the plank.

Draw a line *t p*, to touch the moulds ſo laid down in two places, and as both moulds interſect together at *q*; then draw a ſquare line *p q*, upon the top of your plank, at the ſame diſtance as *p q* is from the bottom ends of your moulds, and this line being ſquared acroſs the edge, and from thence acroſs the under ſide; then ſet the diſtance *p q* on both ſides of your plank, from the ſame edge, and likewiſe ſquare over *t s r*, at the diſtance *p t* on your plank, on both ſides, then ſet the diſtance of *r* from *t* upon the top ſide of your plank, and ſet the diſtance of *s t* upon the under ſide; you will obſerve to mark the point *q* upon both your moulds, then apply your outſide falling mould to the top of your plank, making the point *q* to coincide with the ſame point *q* in the plank, and make the front of the falling mould to come to *r*, and with this mould, placed in this poſition, draw the upper face of your plank with it, and in like manner apply your inſide falling mould, that is, by applying the point *q* to the ſame point *q* in the plank, on the under ſide, and let the front edge be to *s* in the plank; then draw the under ſide; your plank being ſuppoſed of a ſufficient thickneſs, making allowance for the ſaw cuts, and plaining up your veneers, this plank, when cut out twiſted to thoſe lines will be the true form of your veneers: the piece being thus formed, you are to cut your veneers the other way into thickneſſes as you think they will bend eaſy, and ſo I ſhall leave you to complete the rail.

There is one thing that I would have you take notice of here, the general cuſtom among workmen to keep the hand rail higheſt upon the winding part of the ſtairs, on the ſuppoſition of a perſon coming down ſtairs being liable to fall over the rail, when the deſcent is very rapid; and therefore to remedy that inconvenience, I have all along made the under ſide of the falling mould, or the under ſide of the rail, which is the ſame thing, to be equidiſtant upon the rake from the face of the riſers, which will cauſe the upper ſide of the rail to run higher on the rake, than the height of the rail above the common ſteps, and the quicker the aſcent is, the difference will be greater. In laying down this, the diſtance *v w* ſhews how much the winding part riſes above the common ſteps, which is about five inches and a half; this is done by continuing the top line of the rail upon the winding part to *w*, and by continuing the top of the ſtraight part to meet at *v*, then the diſtance of *v w* will always be according to the pitch of the winders.

PLATE LXVIII.

This plate ſhews the method of fitting down the ſkirting, upon any ſort of a ſtair-caſe whatever; whether ſtraight, circular, regular, or irregular; if the treads are ever ſo crooked, and the riſers out of an upright.

In *fig. A*, is ſhewn a bevel, made to the rake of the ſkirting, and the other perpendicular to the ſtair, and a ſliding piece to be applied to the perpendicular ſide of the bevel, with a hooked point of iron or ſteel, to ſtand forward at the bottom ſo much, that the ſliding piece may clear the noſing of the ſtep. I ſhall proceed to ſhew its application.

How to fit down the ſkirting.

Lay the ſkirting over the top of the ſteps, and let a very fine notch be made on the front edge of your ſliding piece, to the height of a ſtep, or rather higher; then apply the point of the ſliding piece to the internal corner of a ſtep, and prick your ſkirting in the notch at *b*, the bevel being ſuppoſed to be brought cloſe to the ſlider: again, ſuppoſing you want to take a point at the noſing, where you ſee the bevel applied under, apply the point of your ſliding piece to the noſing at *c*; then prick your ſkirting in the notch at *d*, that will give the point *d*, which is to correſpond with *c*, &c. and by this means you may take as many pricks as will be ſufficient, till the whole is completed.

COROLLARY. Hence it is evident by the ſame method, that one thing may be fitted into another, whether conſidered as a ſtair-caſe or not, ſtanding either raking, horizontal, or perpendicular.

If the ſteps of a ſtair-caſe be very true, two pricks from each riſer and tread will be ſufficient, as it is only joining theſe pricks by lines, which will form the riſe and tread of each ſtep, and three pricks in each noſe, becauſe a circle may be eaſily drawn through the three points.

If the noſings are all exact, let a mould be made to fit one of them, and your noſings on the ſkirtings be drawn by this mould, which will likewiſe be exact.

FIG. *E* ſhews the method of laying down a raking ſided ſtair, which is clear in itſelf, the height of the ſteps being the ſame on each ſide.

C and *D* ſhews the method of tracing one bracket from another, in a ſtair-caſe: *C* being the bracket for the common ſtep, *D* a bracket for one of the winders.

There is ſhewn a method in the laſt plate, at *E* and *D*, for doing the ſame thing by means of a triangle, which is performed thus: let the other bracket at *fig. D* be given, whoſe length is A B; and if you want a bracket for the winders, whoſe length is B C, draw B C, making any angle at the point *B* join A C; take as many ordinates as you pleaſe, to touch all the principal lines of the given bracket; then draw lines parallel to A C, from theſe ordinates; and complete the other bracket as you ſee by the letters.

PLATE

Plate 68.

This Shows the Method of Skirtining
Any Stair Case

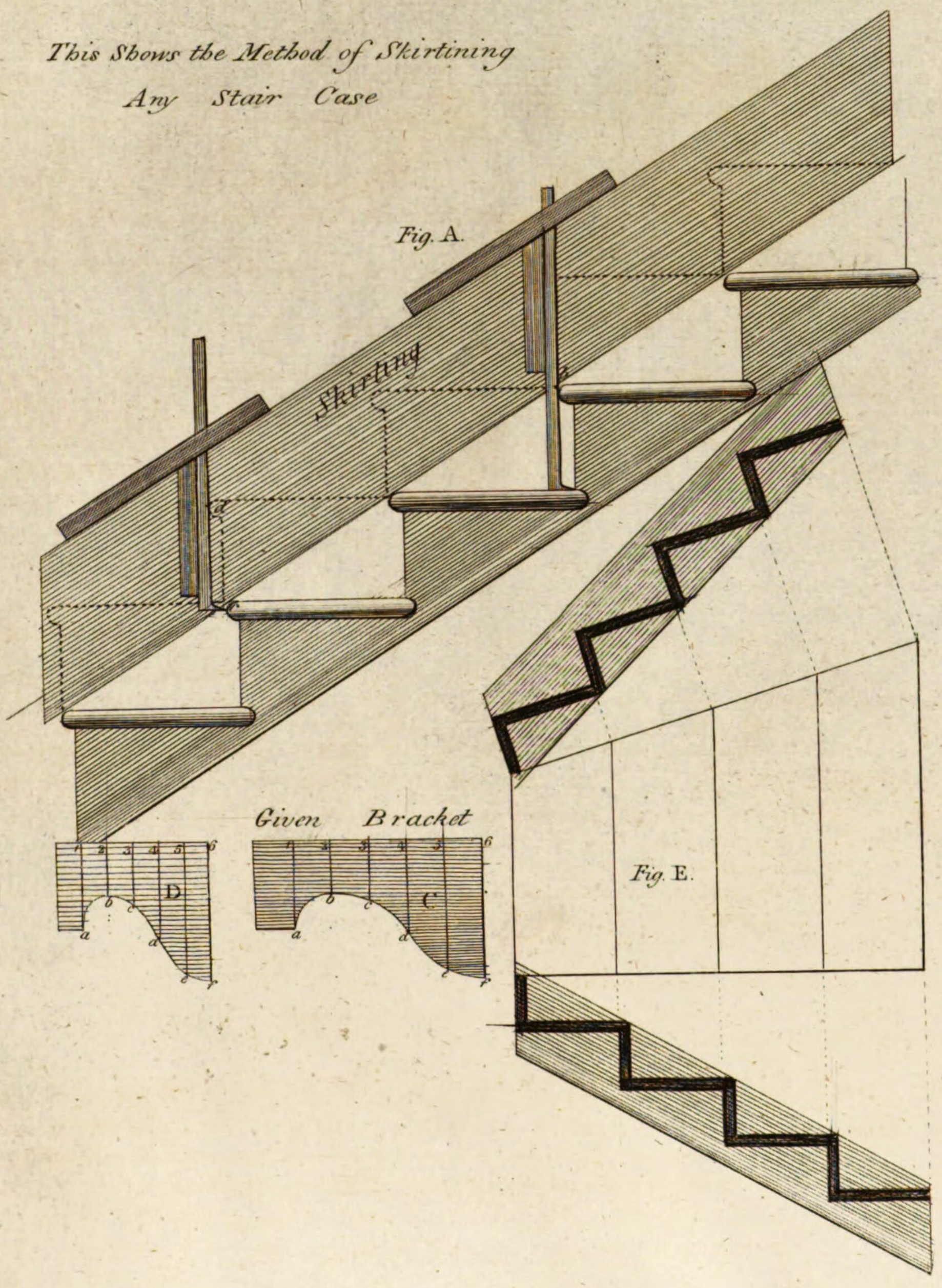

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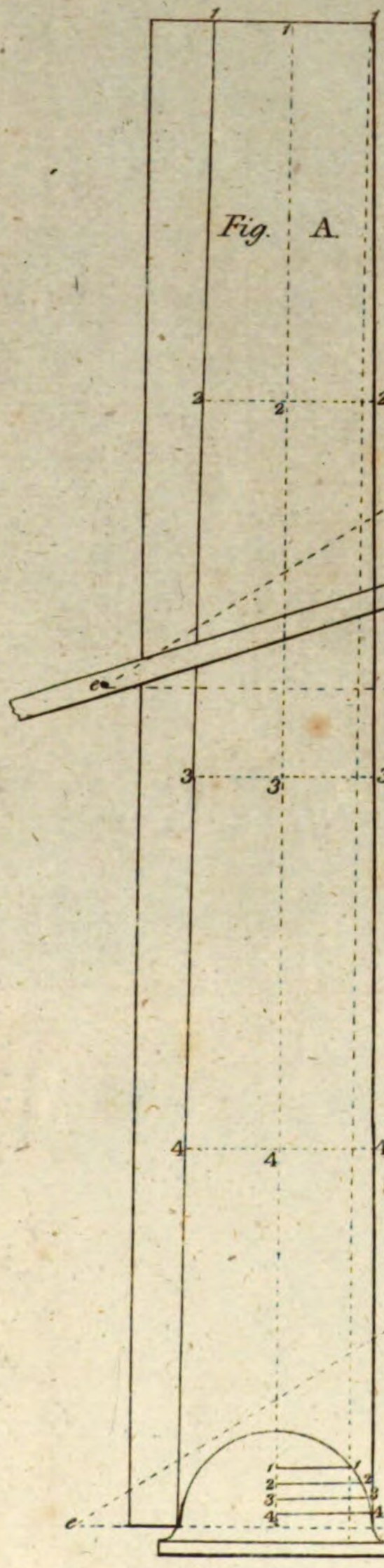
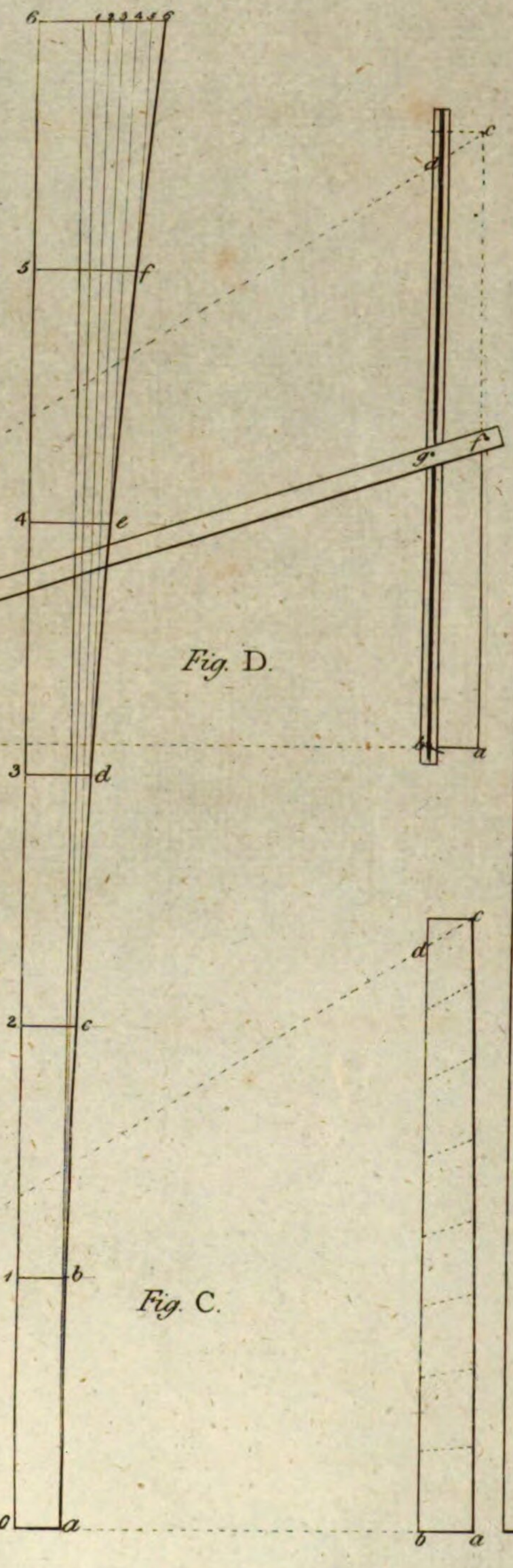
Plate 69.





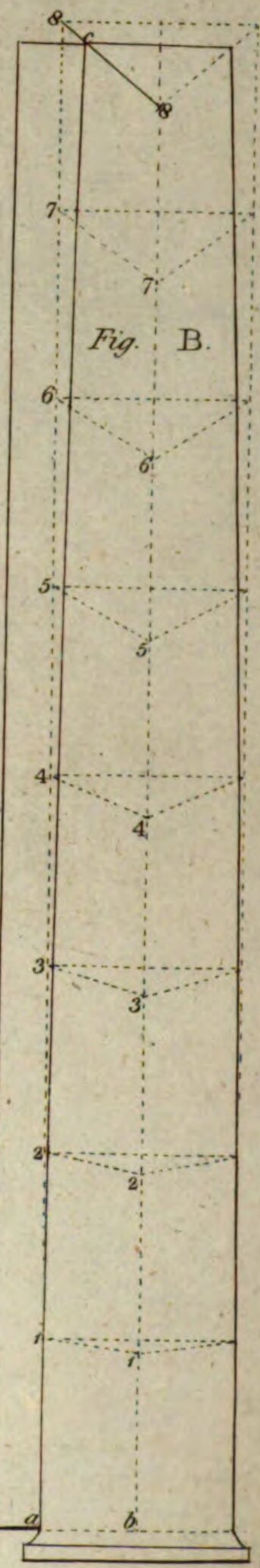


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PLATE LXIX.

How to diminiſh the ſhaft of a column, by the ancient method.

In *fig. A*, deſcribe a ſemicircle at the bottom; let a line be drawn through the diameter, at the top, parallel with the axis of the column, till it interſects the ſemicircle at 1, at the bottom; then 1 1 at the bottom will be equal to 1 1 at the top; divide the arch into four equal parts, and through theſe points draw lines parallel to the baſe, the height of the column being alſo divided into the ſame number of parts, and lines drawn parallel to the baſe, then the column is to be traced from the ſemicircle, according to the figures.

How to diminiſh the column by lines drawn from a centre at a diſtance.

FIG. *C.* Take the diameter *a b*, at the bottom, ſet the foot of your compaſs in *c* at the top, and croſs the axis in the point *d*, continue *c d* at the top, and *a b* at the bottom, to meet at *e*; then draw from *e* as many lines acroſs the column as you pleaſe, and take the diameter *a b* at the bottom, and prick each line upon the axis equal to *b a*, which will give the ſwell of the column.

To diminiſh a column by laths upon the ſame principle.

In *fig. D*, the point *e* being found, as in *fig C*, take and plow a rod *d b*, and lay the grove upon the axis of the column, and plow the deſcribing rod upon the under ſide, and lay the grove upon a pin fixed at *e*, and fix a pin at *g*, to run in the grove upon the axis of the column, and the diſtance of the pencil at *f*, equal to *b a*, then move the pencil at *f*, it will deſcribe the diminiſhing.

How to deſcribe the column by another method.

Take the diameter *a b* at bottom, and ſet the foot of your compaſs in the top, at *c*, and croſs the axis at 8, and draw the line *a* 8 on the outſide, parallel to *b* 8 on the axis, and divide each of theſe lines into eight equal parts, and ſet the diameter *a b* at the bottom along the ſlant lines 1 1, 2 2, 3 3, &c. from the axis; this will alſo give the diminiſhing of the column.

How to make a diminiſhing rule.

Divide the height of your rule into any number of equal parts, as 6; draw lines at right angles from theſe points acroſs the rule, and divide the projection of the rule at the top; that is, half of what the column diminiſhes; into the ſame number of equal parts put a pin or brad-awl; lay a ruler from *a* to 5; mark the croſs line at *f*; then lay a ruler from 4 to *a*, and mark the next croſs line at *e*; then lay the ruler from 3 to *a*, mark the next at *d*, and ſo on to the bottom; bend a ſlip round theſe points, and draw the curve by it, will give a proper curve for the ſide of the column.

Note. This is the readieſt method, and it gives the beſt curve of any that I have tried.

PLATE

PLATE LXX.

The plan and elevation of a circular ſaſh, in a circular wall, being given; to find the mould for the radial bars, ſo that they ſhall be perpendicular to the plan.

Draw perpendiculars from the points 1 1 1 1, &c. at *A* and *B*, in the radial bars, either equally divided, or taken at diſcretion, down upon the plan, to 1 2 3 4 5 6 7, at *C* and *D*; and draw a line from the firſt diviſion upon the backſide parallel to the baſe; then draw ordinates from 1 1 1 1, &c. at right angles to the radial bars, at *A* and *B*, which being pricked from the plans at *D* and *C*, will give a mould for each bar; and the bevels upon the end will ſhew the application of the moulds.

To find the veneer of the circular bar.

To avoid confuſion, I have laid down the plan and elevation for the head of the ſaſh under. The ſtretch out of the veneer is got round 1 2 3 4 5 6, on the circular bar, which being pricked from the ſmall diſtances on the plan at *M*, will give the veneer above, at *E*.

To find the face mould for the ſaſh-head.

Divide the ſaſh-head round, into any number of equal parts, at *G*, and draw them perpendicular to the baſe at *H*; draw the chord of one half of the plan at *H*, and draw a line parallel to it to touch the plan upon the back ſide; then the diſtance between theſe lines at *H*, will ſhew what thickneſs of ſtuff the head is to be made out of; and from the interſecting points on the back ſide, draw perpendiculars from the baſe of the face mould, which being pricked from the elevation, as the figures direct, will give the face mould.

To find the moulds for giving the form of the head, perpendicular to the plan.

The baſe of *L* is got round the arch 1 2 3 4 5 6, at *F*, and the baſe of *K* is got round *a b c d e f g*, alſo at *F*, and the heights of the ordinates of each are pricked either from *H* or *I*, which will give both moulds.

By the ſame method, a circular architrave, in a circular wall, may be got out of the ſolid.

Note. The face mould at *G*, muſt be applied in the ſame manner as in groins; ſo that the ſaſh-head muſt be bevelled by ſhifting the mould *G*, on each ſide, before you can apply the moulds *K* and *L*; the black lines at *K* and *L* are pricked from the plan at *H*; theſe black lines will exactly coincide with the front of the rib when bent round; a line being drawn by the other edge of the moulds, will be perpendicular over its plan, and the thickneſs of the ſaſh frame towards the inſide will be found near enough by gauging from the outſide.

Plate 70.

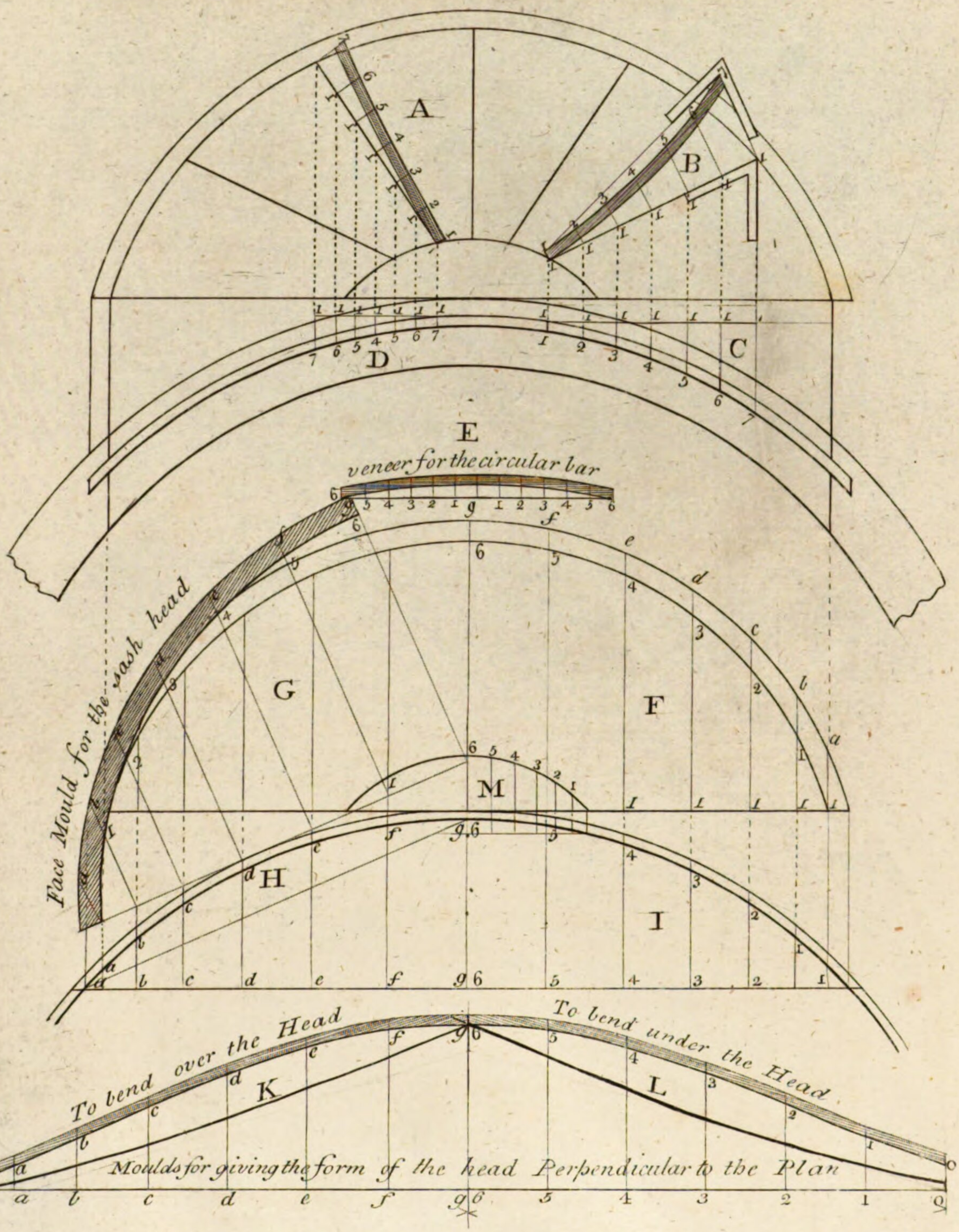

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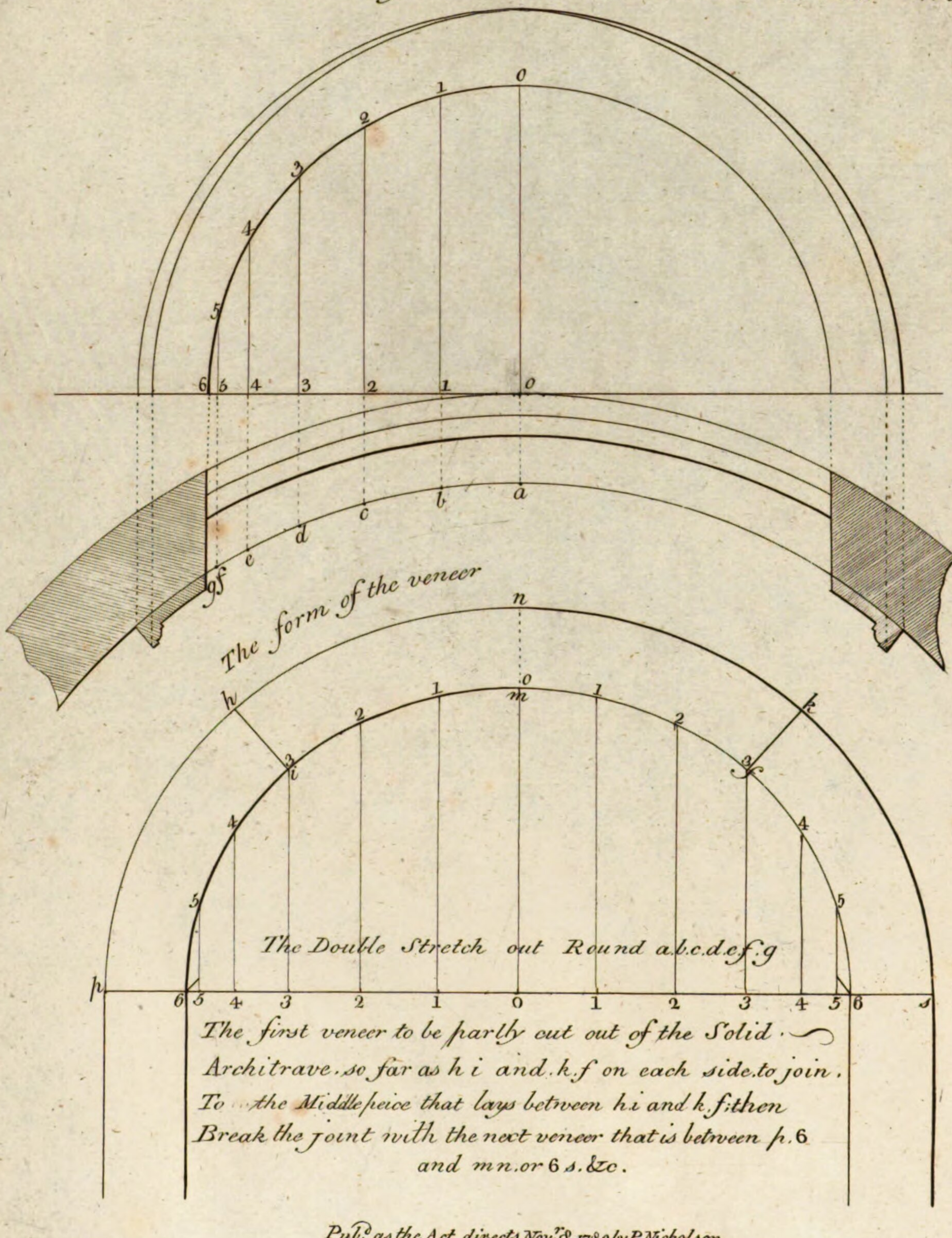
Plate 71.

An Architrave or Archivolt for a Circular Window in a Circular Wall.



The first veneer to be partly cut out of the Solid Architrave. so far as h i and k f on each side to join. To the Middle peice that lays between h i and k f: then Break the joint with the next veneer that is between p 6 and m n. or 6 s. &c.

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Plate 72.

The Method of geting out angle bars for Shop Fronts.

Fig. A.

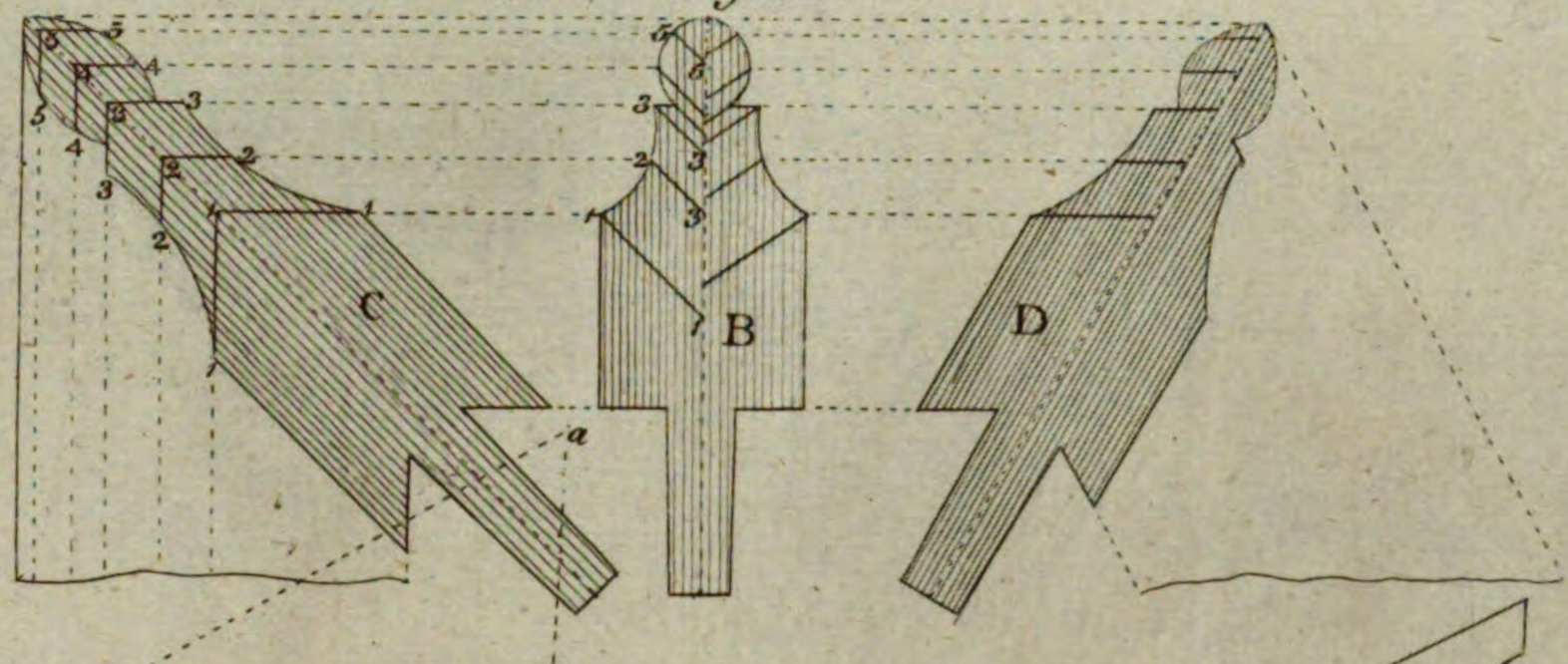

Fig. C.

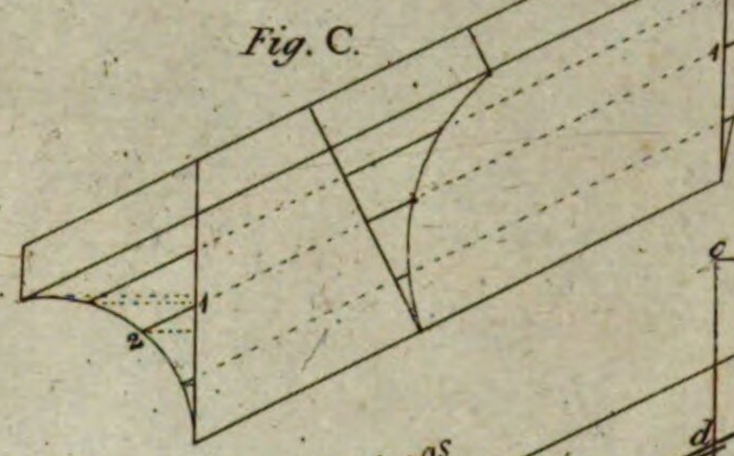

Fig. E.

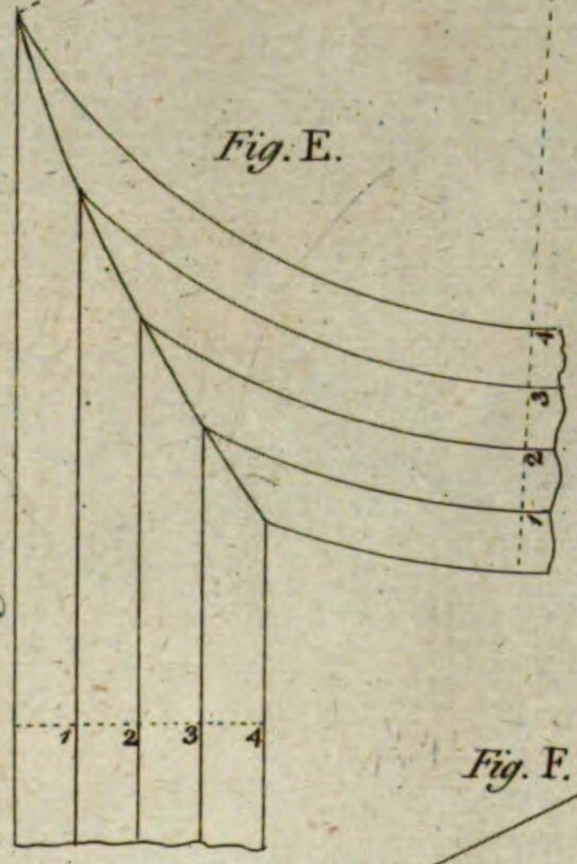

Fig. F.

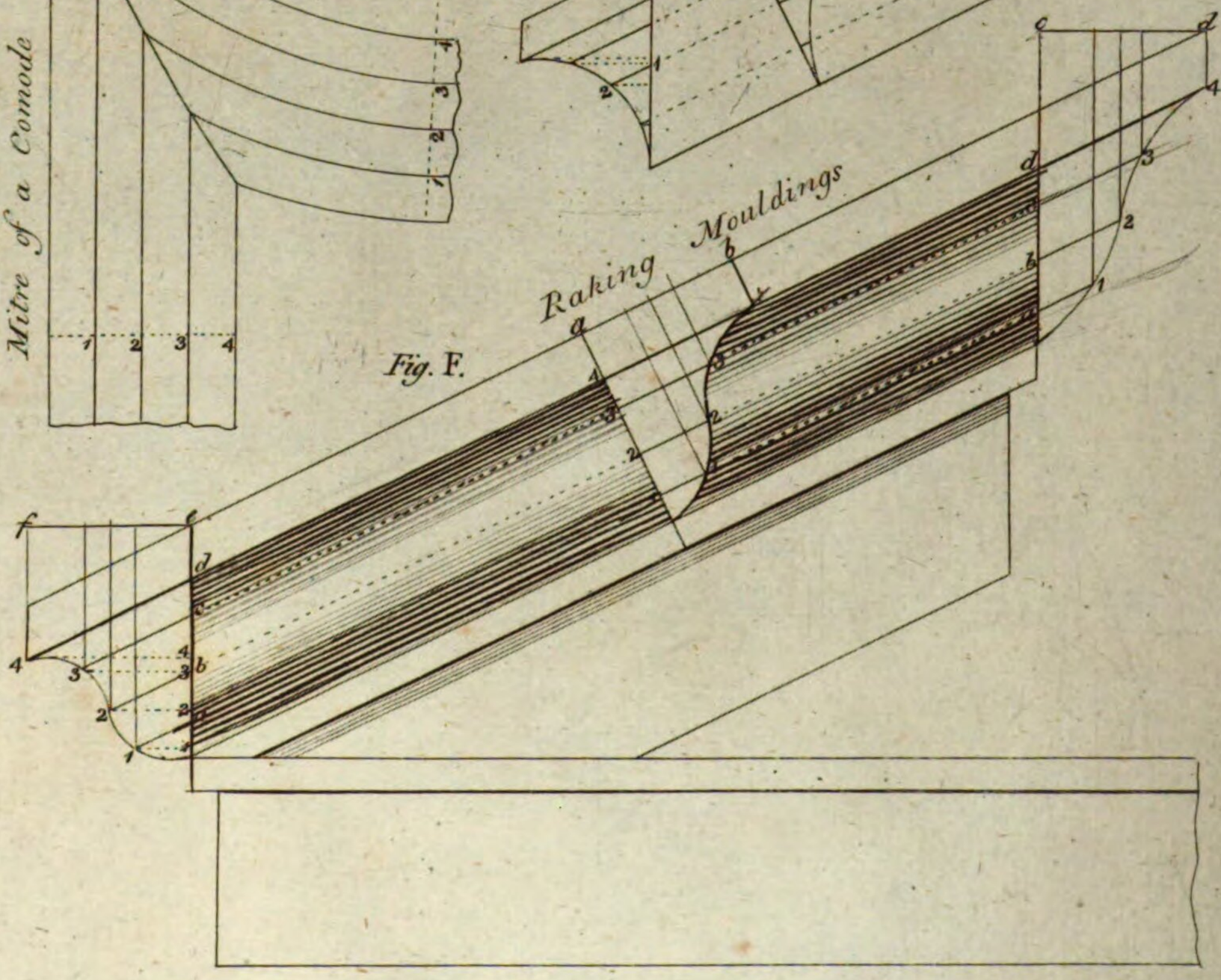

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Plate 73.

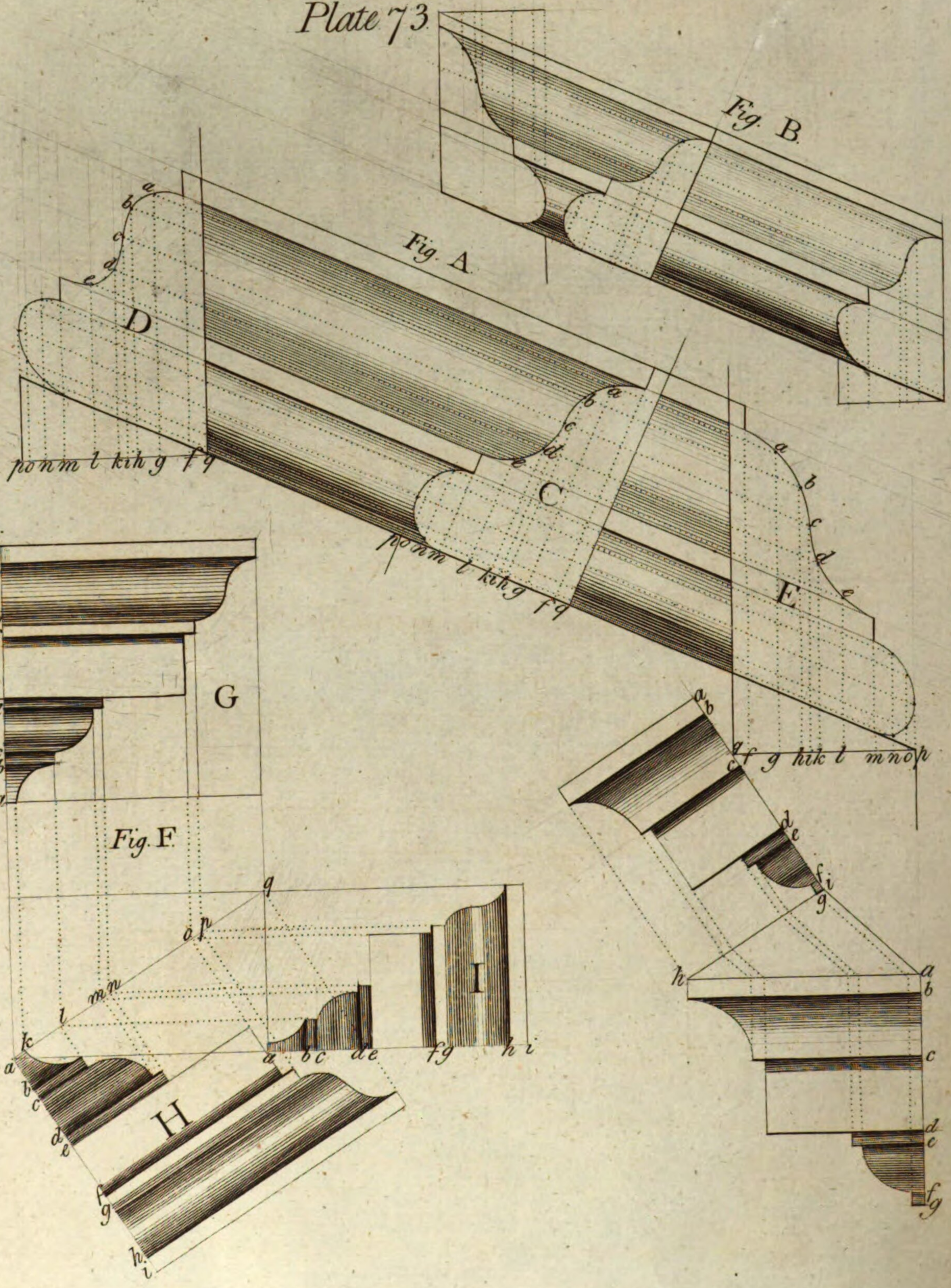


Fig. B.
Fig. A
a b c d e
D
p o n m l k i h g f q
C
E
a b c d e
q f g h i k l m n o p
i h g f
e d c b a
G
Fig. F.
q
a p
m n
l
k
a b c d e
f g h i
H
I
a b c d e f g h i
a b c d e f g
h a b c d e f g

PLATE LXXII.

To deſcribe the angle bars for ſhop fronts.

In *fig. A*, *B* is a common bar, and *C* is the angle bar of the ſame thickneſs; take the raking projection 1 1, in *C*, and ſet the foot of your compaſs in 1 at *B*, and croſs the middle of the bar at the other 1; then draw the lines 2 2, 3 3, &c. parallel to 1 1; then prick your bar at *C* from the ordinates ſo drawn at *B*, which being traced will give the angle bar.

How to draw the mitre angle of a commode front for a ſhop.

In *E* divide the projection each way in a like number of equal parts, then the parallel lines continued each way will give the mitre.

How to find the raking mouldings of a pediment.

In *fig. F*, let the cimiretta on the under ſide be the given moulding, and let lines be drawn upon the rake at diſcretion; but if you pleaſe, let them be equally divided upon the cimiretta, and then drawn parallel to the rake; then the mould at the middle being pricked off from theſe level lines at the bottom, will give the form of the face. The return moulding at the top muſt be pricked upon the rake, according to the letters.

The cavetto, *fig. C*, is drawn in the ſame manner.

N. B. If the middle moulding, *fig. F*, is given, perpendiculars muſt be drawn to the top of the middle moulding; then horizontal lines muſt be drawn over the mouldings at each end, with the ſame diviſions as are over the middle moulding; and lines being drawn perpendicularly down, as above, will ſhew how to trace the end mouldings.

PLATE LXXIII.

Figures *B* and *A* ſhew how to trace baſe mouldings for ſkirtening ſtairs, upon the ſame principle as ſhewn in the laſt plate; at the bottom are given two methods of mitring mouldings of different projections together.

PLATE LXXIV.

Given the form of a cornice to draw it to a greater proportion.

In *fig. A*, let the given height of the cornice be *a b*; ſet one foot of your compaſs in *a*, and croſs the under ſide at *b* with that height, and from the point *c* draw the line *c d* at right angles to *a b*; then the height of all your mouldings will be on *a b*, and the projections on *c d* in proportion to *a b*.

Note, *a f* ſhews another height, *c e* its projection in proportion to that height.

How to diminiſh a cornice in the proportion of a greater.

Deſcribe equilateral triangles on the baſe and projection as at *D*, and make *i f* and *i g* equal to the intended height, and draw the line *f g* acroſs the triangle, which will give the heights in proportion to *a b*; put the foot of your compaſs in *b* as a centre, and circle *b c* round to *b h*, and draw the dotted line *h i*, cutting *f g* in *k*; then ſet off *i e* and *i d*, each equal to *g k*; draw *d e*; then take the diviſions of *e d*, and ſet them from *f* to *m*; in the ſame orders draw perpendiculars: it will give the diminiſhed cornice at *D*.

Another method.

At *E*, let the given height be *a b*, and draw the hypotenuſe *a g*, and lines being ſquared up to *a b*, from the diviſions of *a g*, will give the heights; and if you draw the line *g d* at a right angle with *a g*, then *d c* will give the projection in proportion, when returned upon *d c*.

FIG. C *is the method for hanging a jib door.*

Let *a c* be the projection of the ſurbaſe or baſe moulding, and *c* the centre of the hinge; make *a b* equal to *a c*, and in the centre at *c* deſcribe the arch *b d e*; then the arch *b d e* will be the proper joint for the ſurbaſe to work in.

The joint of the ſurbaſe or the baſe may alſo be ſtraight, as you ſee by the dotted line touching the circle at the point *b*, as a tangent to it.

PLATE LXXV.

To find the ſweep of a moulding to be bent upon the ſpring round a circular cylinder.

In *fig. A*, which ſtands upon a ſemicircular plan, ſet *a c* to the height of your moulding, and make *a b* the projection; draw the form of your moulding, and draw a dotted line to touch the face of your moulding; then draw the line *e d* to meet in the centre of the body at *d*, ſo as to keep your moulding to a ſufficient parallel thickneſs; then in your centre *d* deſcribe your moulding.

How to find the ſweep of your moulding when the plan is a ſegment.

Complete the ſemicircle as in plate 1, *fig.* 1, then proceed as deſcribed in *fig. A*.

FIGURES *C* and *D* ſhew the method for bending a moulding round the inſide, which is performed the ſame as above.

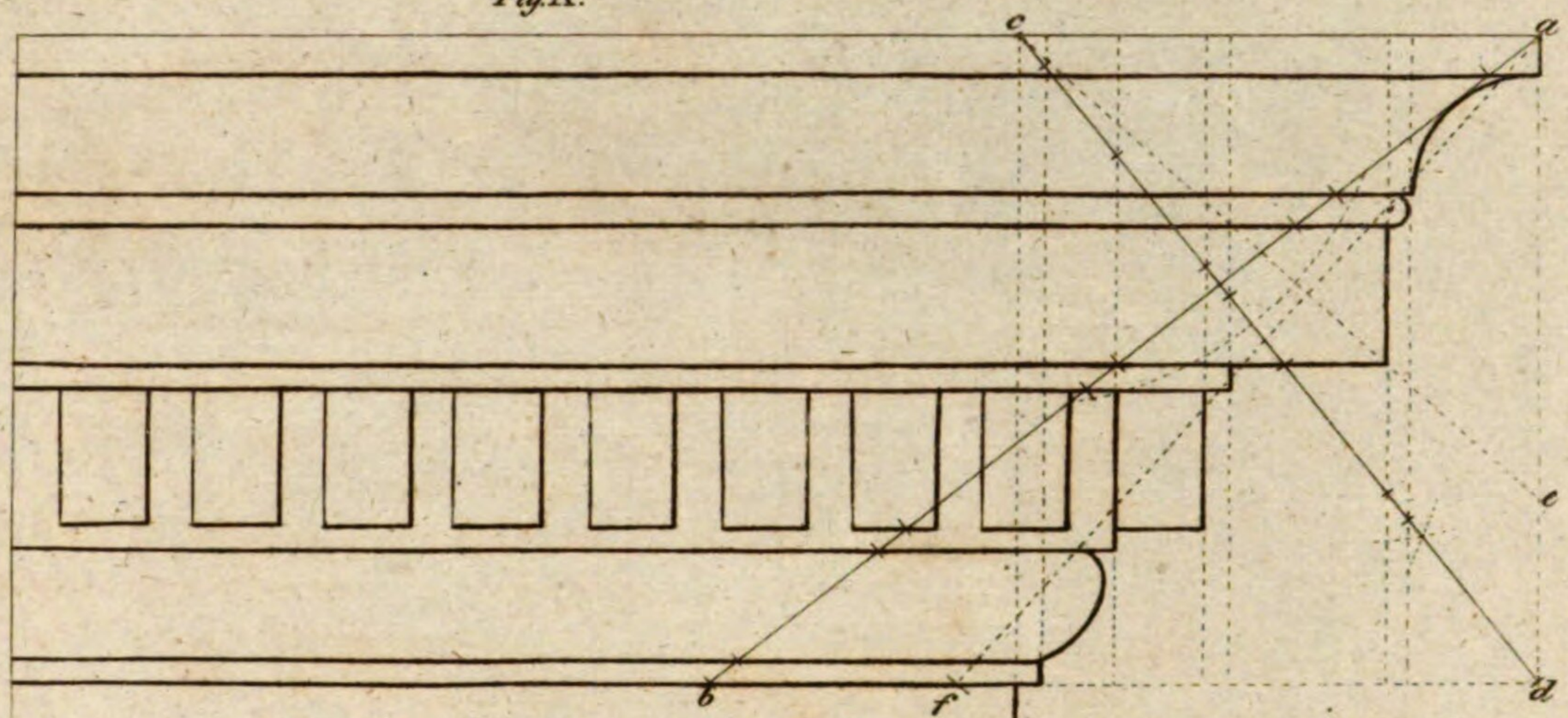
The demonſtration may eaſily be conceived from the covering of a cone.

CON-

Plate 74.

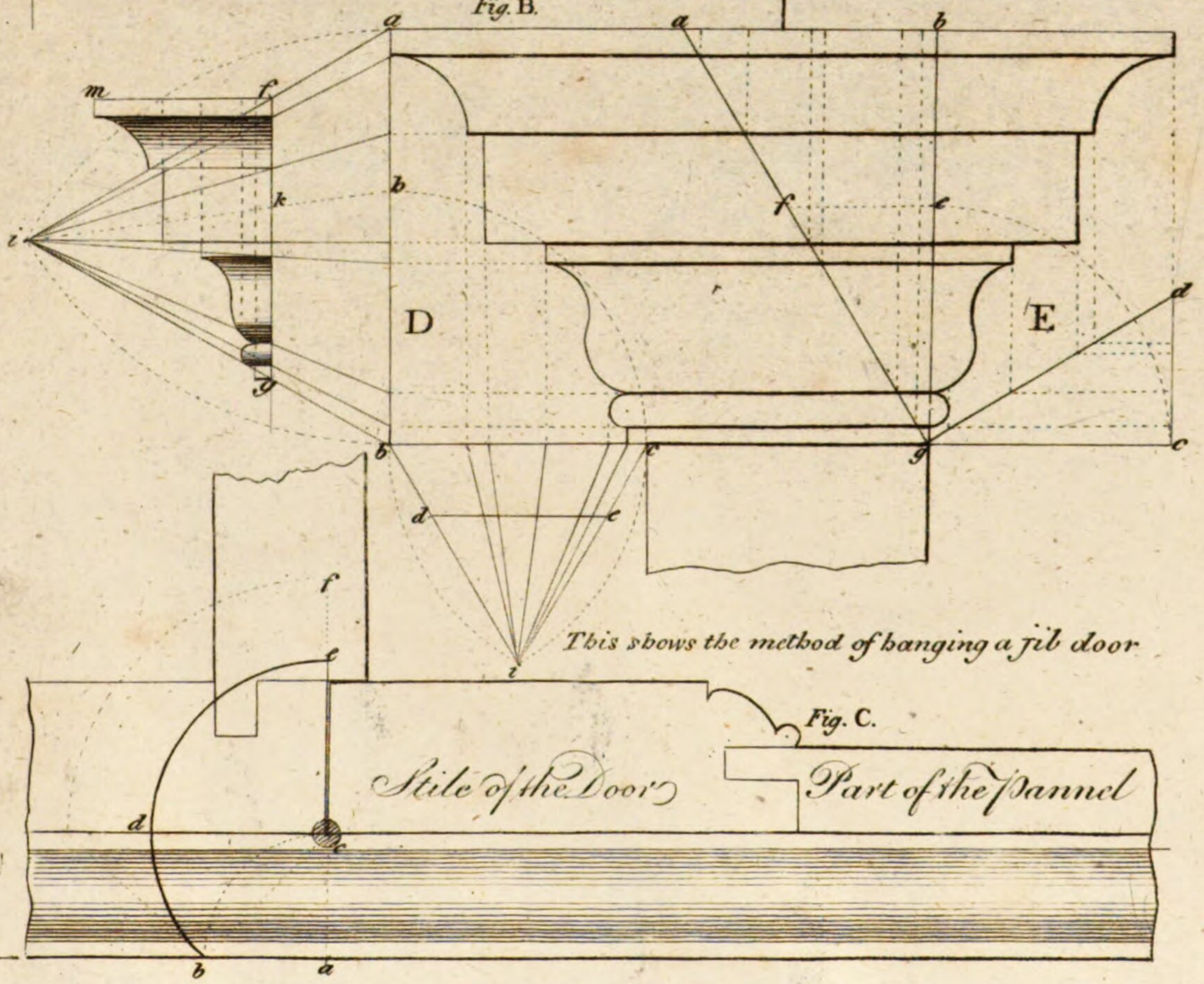
This shows the method of enlarging cornices.

Fig. A.



This shows the method of diminishing cornices

Fig. B.



This shows the method of hanging a jib door

Fig. C.

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Plate 75.

Fig. A.

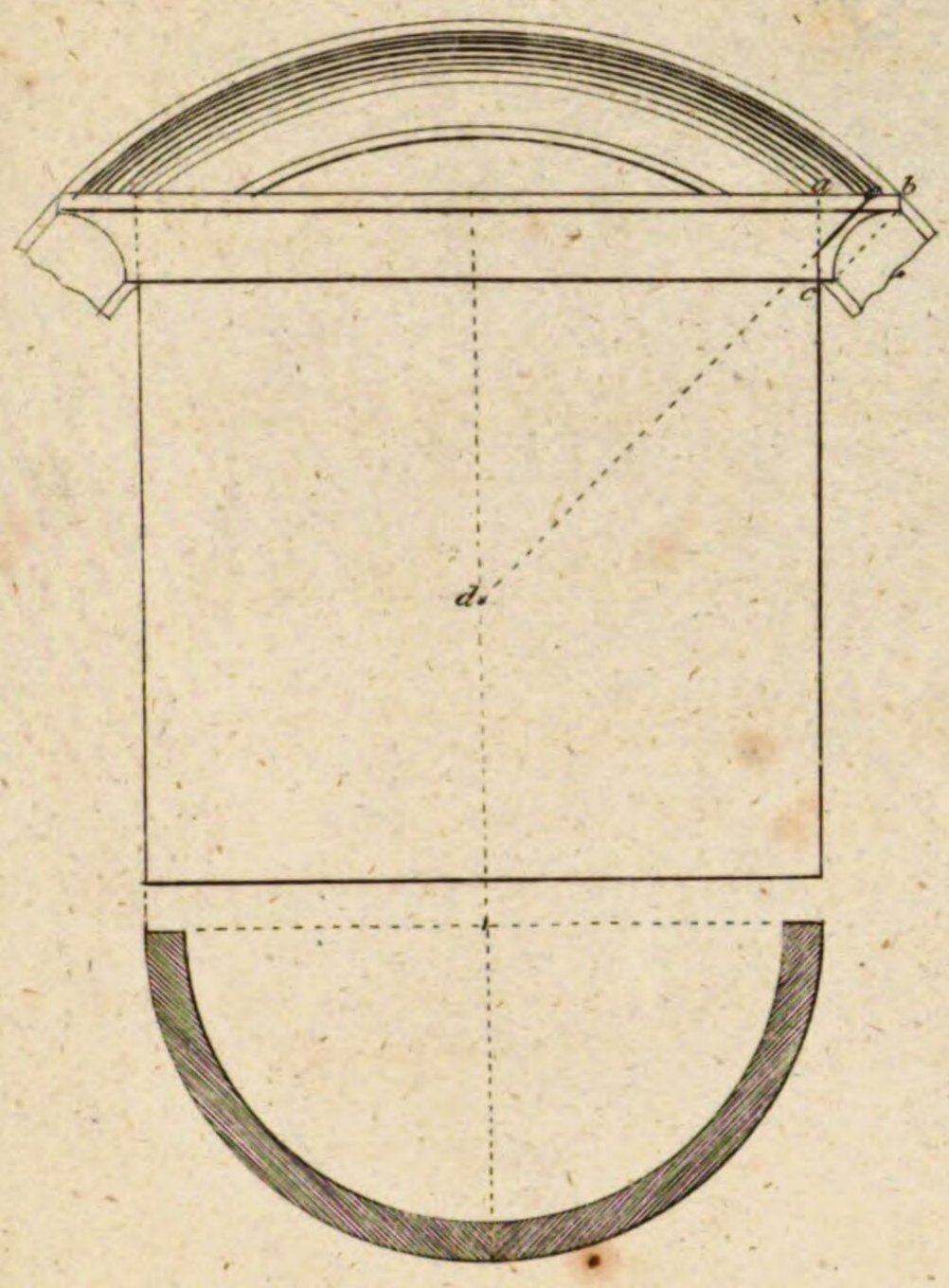
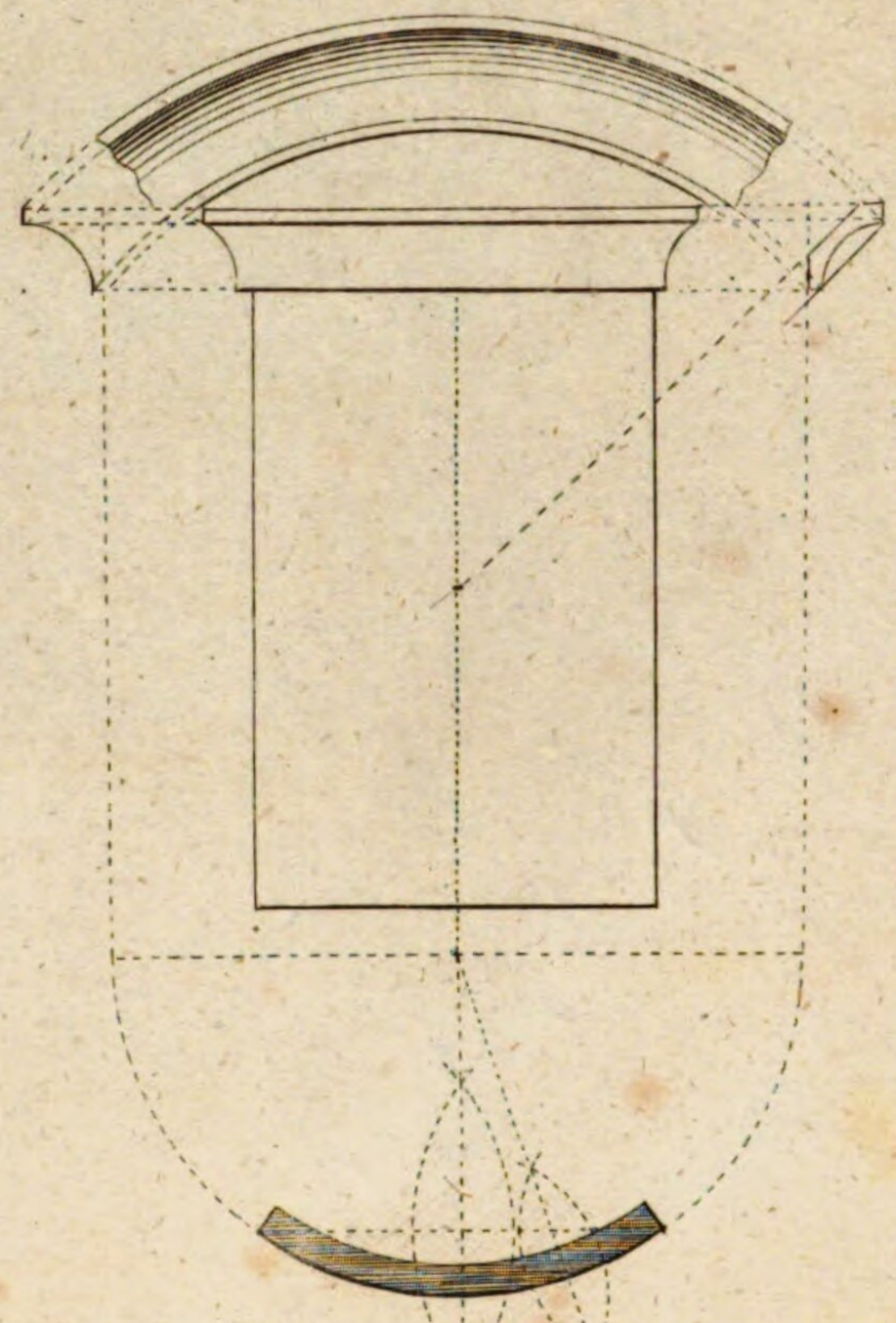


Fig. B.



This Plate shows the different methods of bending cornices out of the solid. to stand to any Spring

Fig. C.

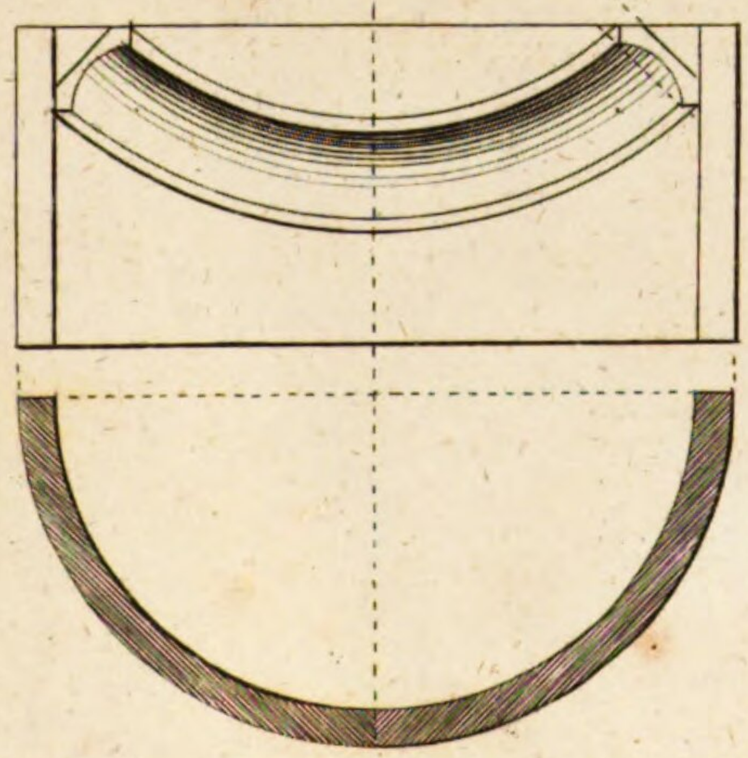


Fig. D.

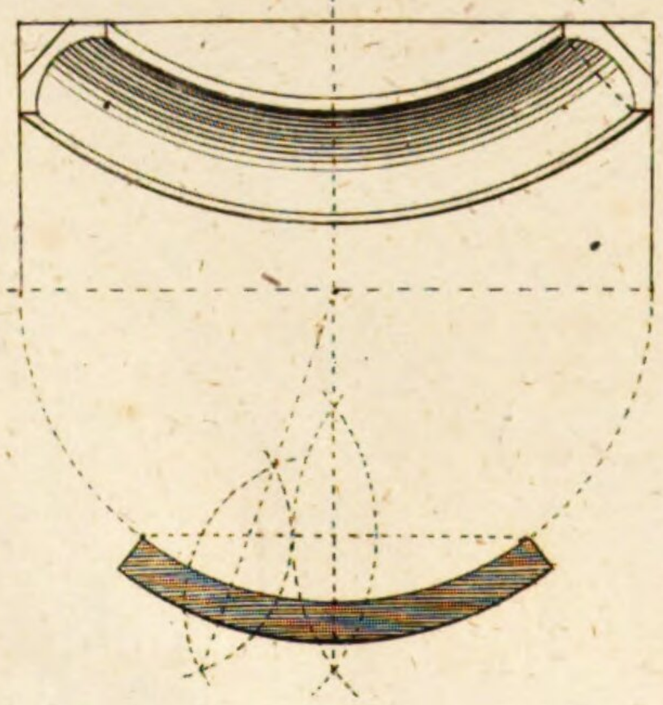


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Plate 76

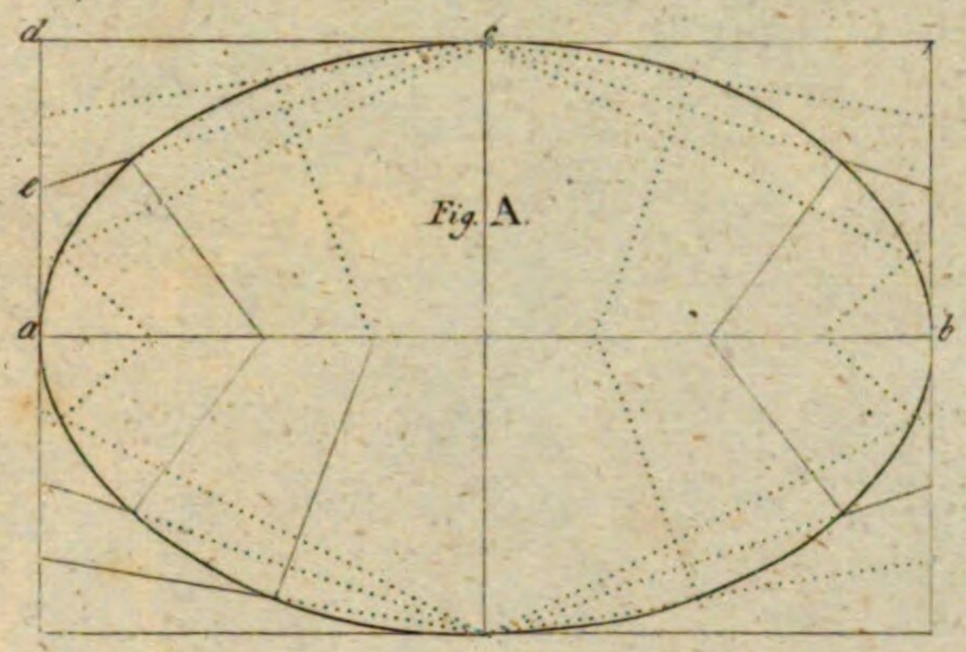


Fig. A.

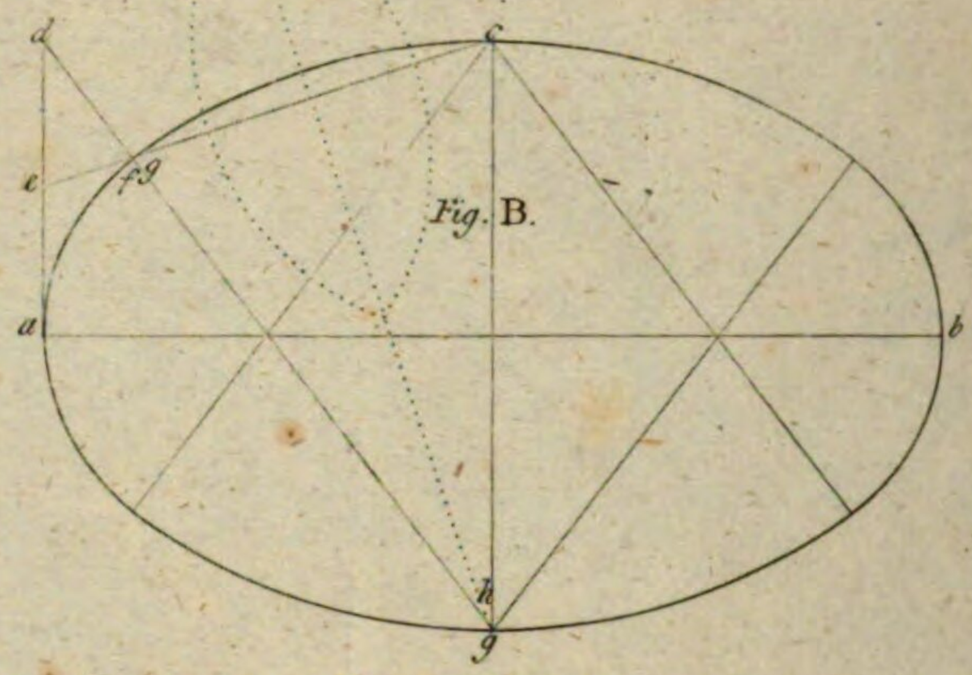


Fig. B.

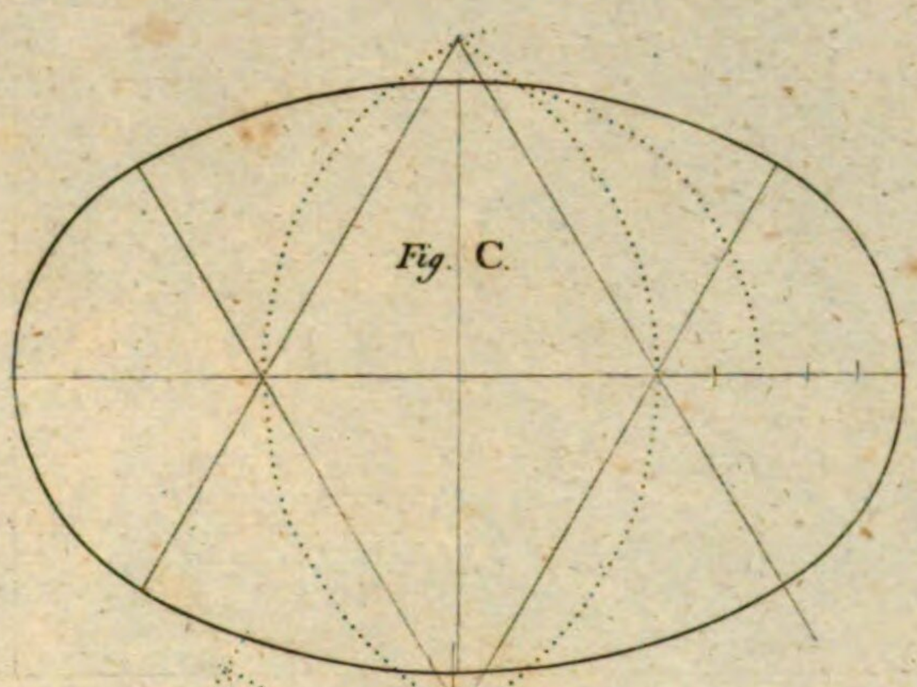


Fig. C.

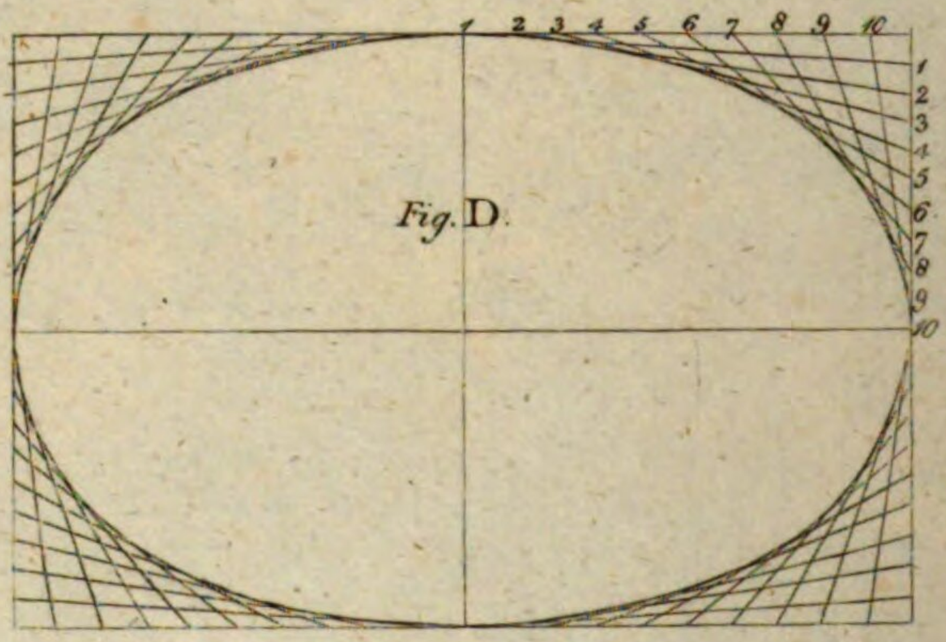


Fig. D.

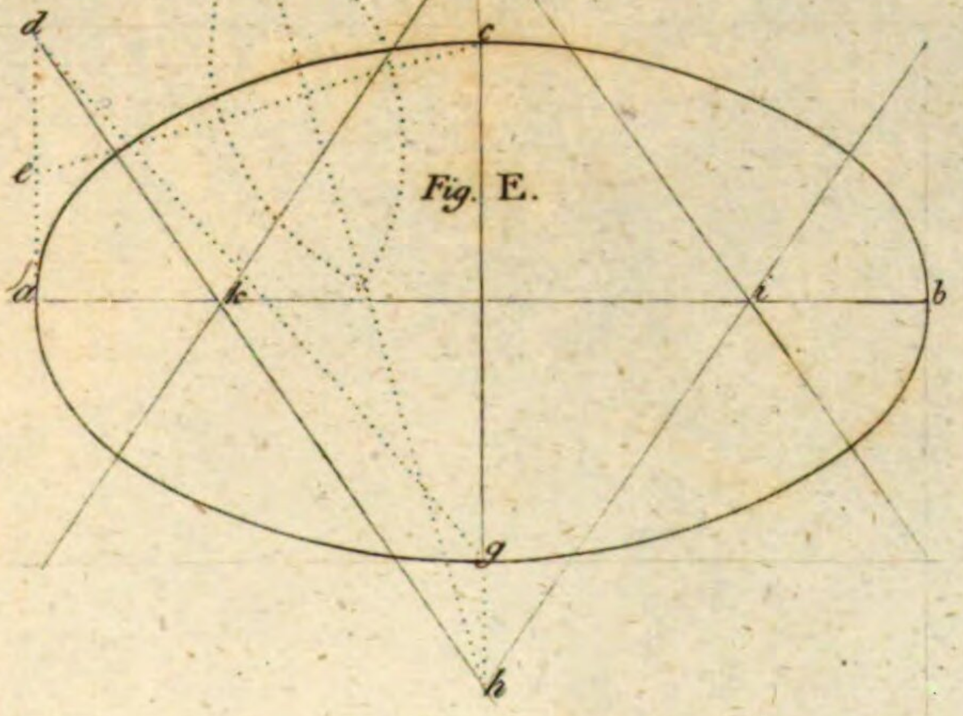


Fig. E.

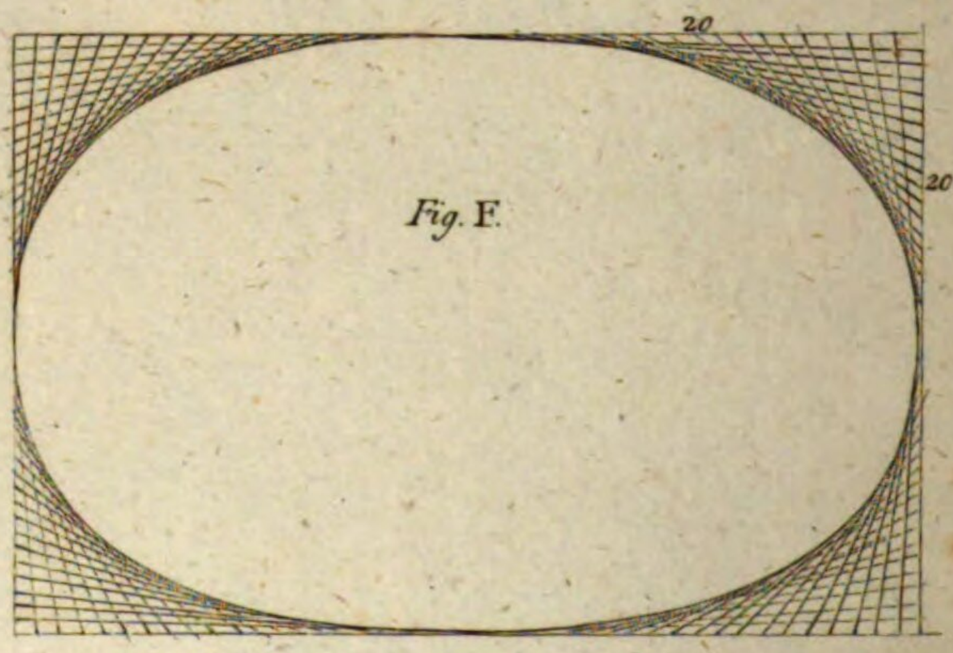
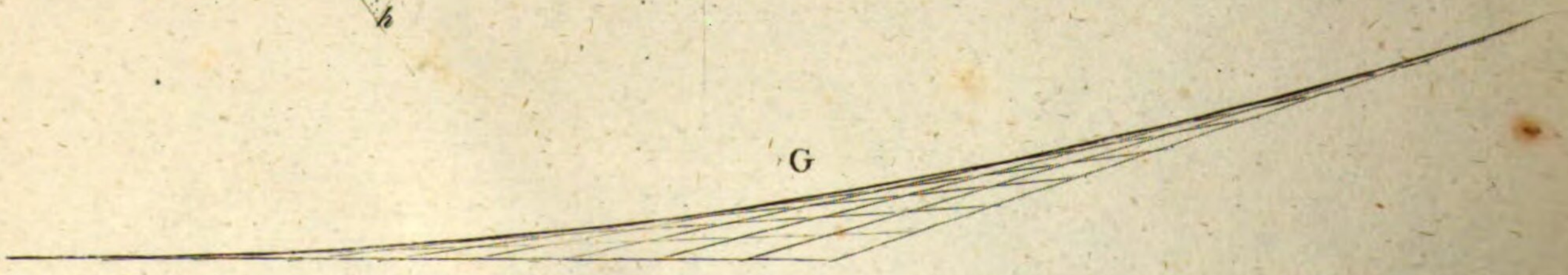


Fig. F.



G

Plate 77.

Fig A

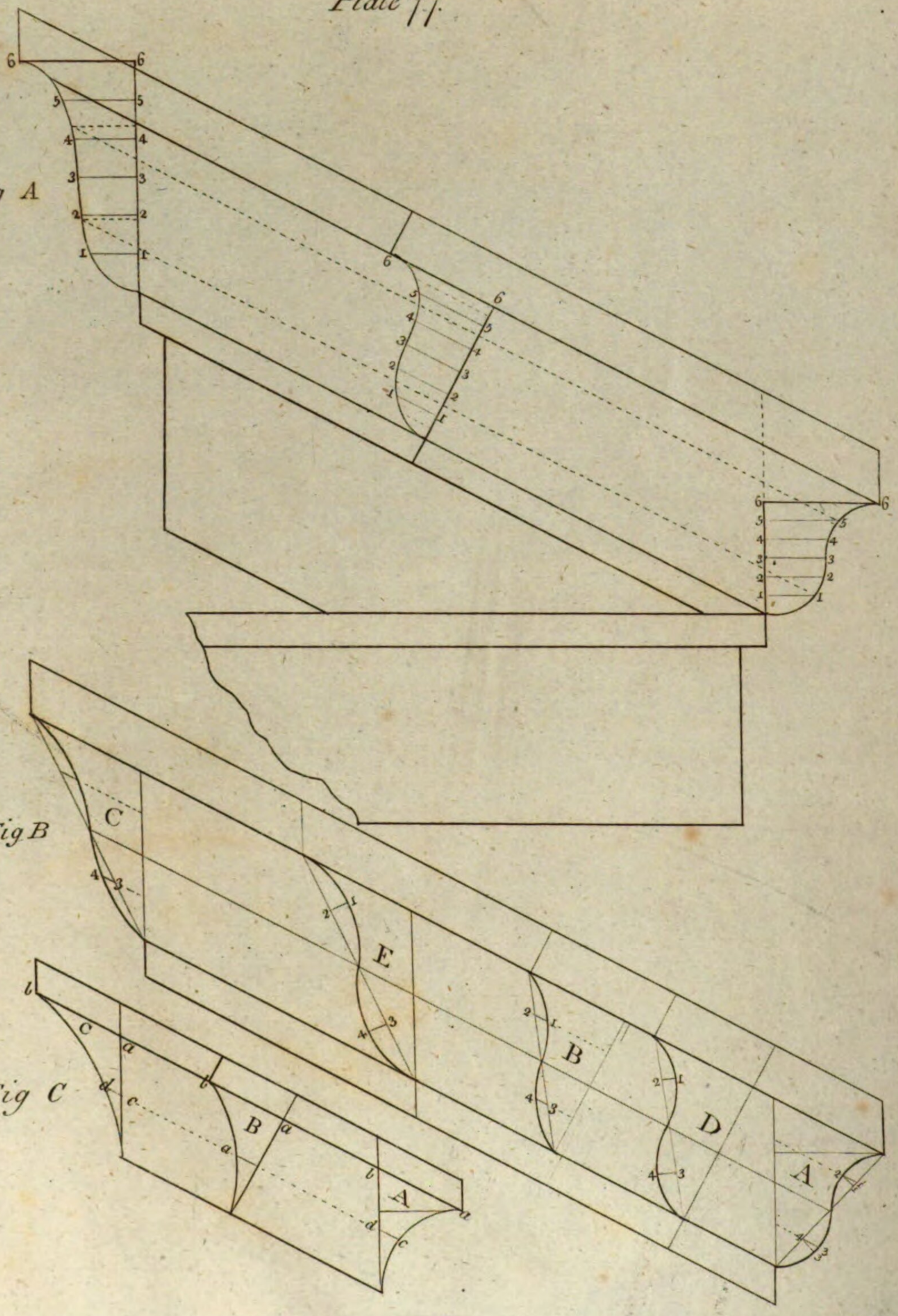


Fig B

Fig C

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CONCLUSION:

In which are examined, by way of preventive Caution to the Student, ſeveral prevailing Methods, which are founded on wrong Principles, and better ones here propoſed.

Of the Ellipſis. Plate 76.

THE old manner of interſecting all kinds of lines, applied to gothic and elliptical figures, to this day is exceedingly uſeful in forming the ramps of ſtairs, or eaſing off any angle, as at *G*; but when this is applied to elliptical figures, it is far from forming a true ellipſis, being too full at the ends, as at *fig. D* and *E:* and this is no certain rule for drawing an ellipſis, for the more diviſions there are, the worſe is the ellipſis; as for example, *fig. F* is divided into double the number of parts as *D*; it is plain that neither *D* nor *F* is an agreeable ellipſis, and *F* is much worſe than *D*, which is contrary to general opinion; for I have been frequently told, the more parts it is divided into, the truer it is; but by this it appears the more parts it is divided into, the worſe it is: if this is doubted, try it. *Fig. A* is an ellipſis drawn on true principles, as laid down in Plate 7, at *C*, of this book, and is here repeated to be compared with the others. *Figures B, C,* and *E,* are ellipſes drawn with a compaſs: I may call them repreſentations, as it is impoſſible to draw them true with a compaſs; there is no part of the curvature of an ellipſis that will exactly agree with any part of a circle, for in every quarter of an ellipſis, from the extremity of the tranſverſe, the curvature in every ſucceeding part is continually flatter towards the extremity of the conjugate axis; but yet there is a method to repreſent an ellipſis, which will differ very little from the truth, as is ſhewn at *figures B* and *E,* which are both drawn by the ſame method; *fig. E* or *B* is the neareſt to the ſhape of *fig. A*; *fig. C,* the method uſed by almoſt every author who has written upon the ſubject, is full at the ends, but not in ſo great a degree as *fig. D* and *E.*

Of raking Mouldings. Plate 77.

In Plate 77, *fig. A,* let the moulding at the bottom be given, and let the perpendicular height be divided into any number of equal parts, as ſix; likewiſe divide the perpendicular height of the top moulding into ſix, and the face moulding into ſix, at right angles to the rake; and let the ordinates of each be drawn through the equal diviſions of each reſpective perpendicular, and pricked from the bottom, as the figures direct. It is evident, that if the under moulding is compoſed of two quarters of a circle, the upper mouldings will be compoſed of two quarters of an ellipſis; conſequently the return moulding at the top will be too quick upon the round, and likewiſe in the hollow.

But

But if this demonſtration ſhould not be ſufficient, let a dotted line be continued from 1, in the given moulding, parallel to the rake; then it will be evidently ſeen, that this dotted line correſponds with neither the face nor the return moulding; for in the face moulding it falls between the points 1 and 2; and in the top moulding it falls almoſt at the point 2; whereas it ſhould only come to the point 1 in each; but the horizontal projection from 2 to 2, at the top, ought to be equal to 1 1 at the bottom; but it is much greater: therefore this method is falſe, as they will not mitre together.

I ſhall alſo notice another method uſed by ſome authors, ſee *figure B*, at *D* and *E*, where they are pricked perpendicular to their chords, in the middle, which is alſo falſe; but if they are pricked as at *B* and *C*, on the rake, will be exceedingly near, if deſcribed with a compaſs through three points.

Of diminiſhing of Columns. Plate 78.

The method for drawing a column, deſcribed by ſome authors, and which is properly called a conchoid column, is not only very inconvenient on account of the cumberſome inſtrument which is neceſſary to find the curve for practice, but alſo the appearance is, I think, leſs graceful than when produced by other methods. The conchoid curve, or column, is concave towards the bottom, and convex towards the top; and if this curve was infinitely extended, it would never meet the axis; which ſhews it to be different from the elliptic curve or column, as ſome have called it.

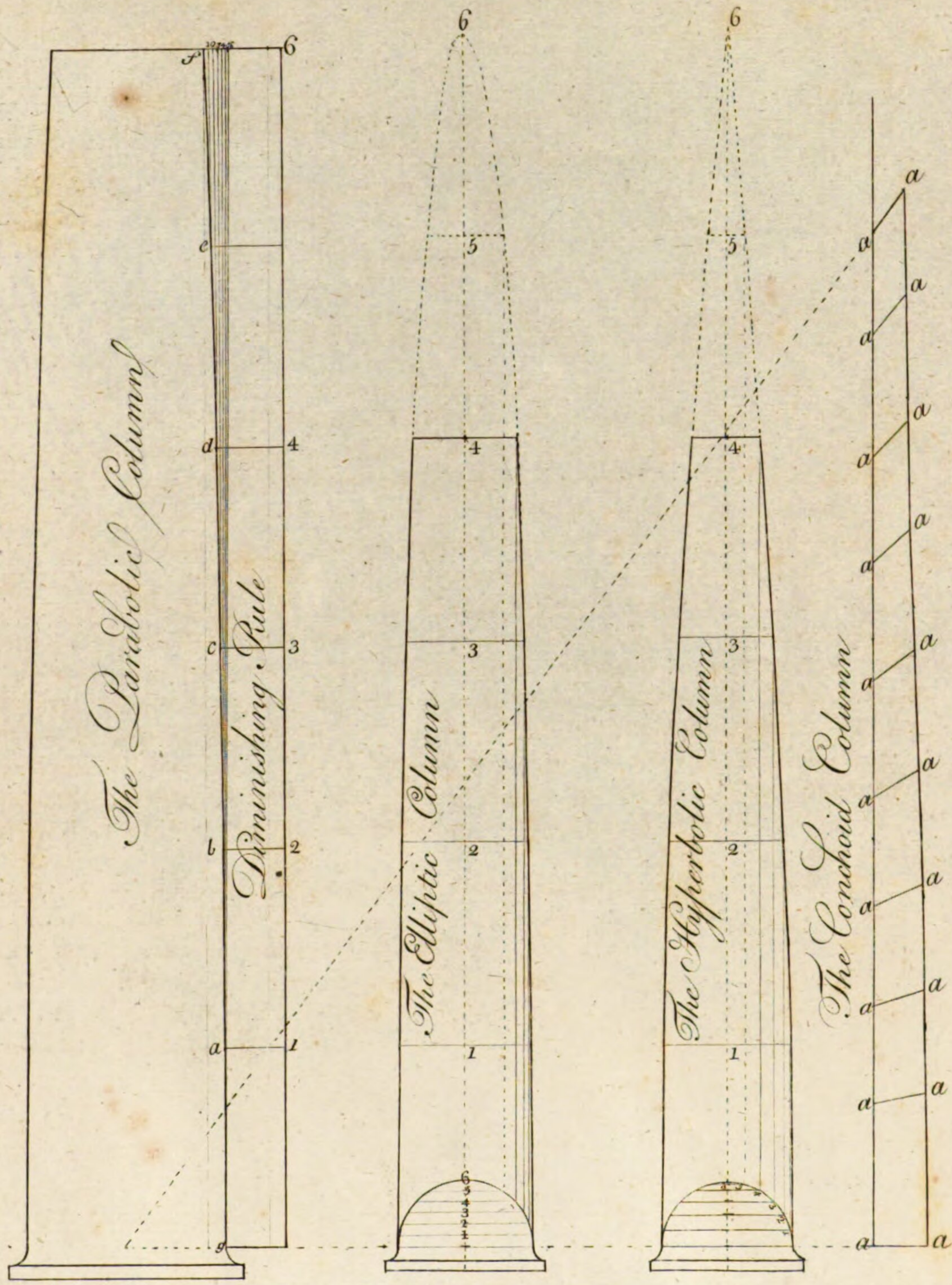
The column called hyperbolic, plate 78, is not ſo named from the general properties of the conic hyperbola (becauſe there may be an infinite number of hyperbolas ſtanding upon the ſame baſe, having one common vertex, which will all be contained between a triangle and a parabola, according as its axis is longer or ſhorter), but becauſe it will nearly coincide with ſome of theſe hyperbolas. This curve has been known among workmen, and by them has been miſtaken for an elliptic curve; to refute which I have, on the ſame plate, ſhewn a true elliptic column for compariſon; the lines of their curvature are continued only to ſhew their true figure; either of theſe is a more commodious method than the conchoid.

The method which I recommend as eaſieſt in practice for diminiſhing of columns is already deſcribed on plate 69, by means of a diminiſhing rule, which is infinitely more convenient than the trammel, and which, to my eye, alſo produces a pleaſanter contour; but as this will depend on the fancy of the architect, the workman will find ſome of the methods ſhewn will anſwer his purpoſe for any curve. The conchoid is flatteſt at the top, the hyperbolic is a little quicker, the parabolic is ſtill more ſo, and the elliptic is the moſt quick.

FINIS.

BAYERISCHE STAATS- BIBLIOTHEK MUENCHEN

Plate 78



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Nicholson, Peter, 1765-1844

The Carpenters New Guide being a complete book of lines for Carpentry and Joinery

London 1793

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